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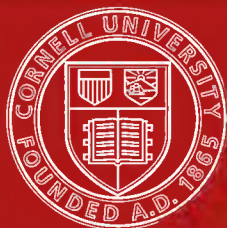
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The mineral industry of the British Empire



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IMPERIAL MINERAL RESOURCES
BUREAU.

THE MINERAL INDUSTRY OF
THE BRITISH EMPIRE

AND

FOREIGN COUNTRIES.

WAR PERIOD.

ZINC.

(1913-1919.)



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PREFACE.

The following digest of statistical and technical information relative to the production and consumption of Zinc will constitute a part of the Annual Volume on the Mineral Resources of the British Empire and Foreign Countries.

In the first year of publication an effort has been made to fill in, as far as possible, the hiatus in the publications relating to mining and metallurgical statistics due to the war. Labour, health and safety statistics have been omitted owing to the difficulty involved in procuring reliable information over the war period, but in future issues such statistics will be included in respect of each year.

Use will also be made, to a much greater extent than at present, of graphical representation of statistics of production, consumption, costs and prices.

The available statistics relative to all minerals and metals during the period under review, viz., 1913-1919 inclusive, are, as is well known, incomplete owing to war conditions, but it is hoped that in future issues of the mineral conspectus, to be published annually, it will be possible to make a more complete statement. More space, too, will be devoted to potential resources.

In the case of all metals, and particularly so as regards zinc, economically effective production depends largely on three main factors, viz. :—(a) ore supplies, (b) fuel or power, (c) labour, and the farther a country departs from these essentials so is it the more difficult to keep alive the industry on an economic basis.

The British zinc industry at the present day is in a depressed state. The South Wales smelters have been closed recently, and the works at Seaton Carew are apparently being kept in operation for the purpose of maintaining a nucleus of technical staff and labour, but the new smelting works near Birmingham continue in full operation.

The Bureau has been fortunate in securing a valuable contribution from the pen of Mr. Gilbert Rigg on some special aspects of the zinc industry at the close of 1919.

The Governors are indebted to the Technical Committee on Zinc, and especially to the sub-committee thereof (Messrs. Moulden, Ridge and Sulman) for the time and trouble they have devoted in passing this work for the Press.

R. A. S. REDMAYNE,

Chairman of the Governors.

2, Queen Anne's Gate Buildings,
London, S.W.1.

December, 1920.

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GENERAL.

Zinc is a bluish-white metal with a crystalline structure. At ordinary temperatures the cast metal is brittle, but it becomes malleable when moderately heated; it can then be rolled into thin sheets or drawn into wire. Zinc has an atomic weight of 65.37, and a fluid density of about 6.5. When cast zinc is poured at or near its melting point ($415^{\circ}\text{C}.$), and cooled slowly, it has a sp. gr. of about 7.125. By rolling, the sp. gr. is increased to 7.2.

The chief zinc-bearing minerals are zinc-blende (the sulphide), calamine (the carbonate), and hemimorphite (the hydrated silicate). Franklinite (oxide of zinc, iron and manganese), willemite (zinc silicate), and zincite (oxide of zinc) are found abundantly only at the Franklin Furnace mine, New Jersey, U.S.A. The Franklin Furnace ore is, on account of its purity, specially adapted for the manufacture of high-grade zinc and zinc oxide.

Other zinc minerals that may be mentioned are goslarite (hydrated zinc sulphate) and hydrozincite (hydrated zinc carbonate), both of which occur as secondary minerals in many old zinc mines.

Zinc-blende is usually associated with other sulphide minerals. Galena, which is generally argentiferous, is almost invariably present, as also is iron-pyrites; copper-pyrites, which may be auriferous, is sometimes present.

The term "calamine" is often used by zinc smelters to describe oxidized zinc ores generally—*i.e.*, the carbonate and silicate. Formerly these were the ores principally used in this country for the production of spelter, mere calcination (to expel water and carbon dioxide) being required to prepare the ore for distillation. With the gradual reduction in the available supplies of calamine, smelters have utilized roasted blende in admixture with calamine ores, and in some instances have lately employed sulphide ore alone. The roasting of blende to an oxide product sufficiently free from sulphur is a more lengthy and expensive operation than the calcination of calamine, whilst prevention of the escape of sulphur dioxide from the roasting furnaces into the atmosphere is now likely to become imperative.

Of late years, especially during the war, the distillation of complex zinc-lead-silver ores ("Australian" or "flotation" concentrates) has been increasingly practised in England, mainly at Seaton Carew, though in smaller quantities and in admixture with other zinc ores, in other districts. Similar flotation

products have been treated at Anaconda (U.S.A.) and at Trail (B.C.) by hydrometallurgical and (partially) distillation methods. The bulk of the Australian Broken Hill zinc concentrates has hitherto been smelted in Belgium, while a smaller part was formerly treated in Germany. It is probable that in future the world's output of metallic zinc will depend in large degree upon the utilization of the more or less complex zinc-sulphide ores; from this aspect the zinc industry is, therefore, likely to become even more closely linked with that of lead and of silver.

By far the largest proportion of the world's supply of zinc is obtained by the distillation process, by means of which the zinc contained in the ore is volatilized at a heat approaching whiteness and condensed as liquid metal in clay receivers attached to the retorts. In recent years efforts have been made to improve the methods of zinc extraction by eliminating the excessive amount of hand labour required in the retort method of distilling zinc ore.

Attention has been directed to the several methods proposed for "continuous" retort operation, to electrothermal processes, where distillation is effected by heat produced within the furnace or retort itself; also to hydrometallurgical methods whereby the zinc is rendered soluble in dilute acid, and the completely purified solution submitted to electrolytic deposition for the recovery of the metal, a nearly pure product resulting, which during the war commanded a substantial premium. For all electrical reduction methods cheap electrical power is essential; and it has occasionally been found more advantageous to transport the roasted concentrates to smelters equipped with electric power-plant, than to reduce such ores at the roasting centre. Plant for electric power, whether hydro-electric or steam-generated, demands a heavy capital outlay, and in the case of steam-generated power, cheap fuel. For these reasons electric reduction methods in England are impossible under present conditions.

The industrial uses of zinc, or spelter as it is known commercially, have increased greatly during recent years. Formerly zinc was valuable chiefly for alloying with copper, tin and lead, but the discovery of the galvanizing process whereby a superficial coating of zinc can be applied for the protection of iron sheets, wire, and other articles, gave an enormous impetus to the consumption of zinc. Probably 65 per cent. of the total zinc smelted is used in the process of galvanizing.

Zinc at a temperature between $100^{\circ}\text{C}.$ and $150^{\circ}\text{C}.$ can be rolled into thin sheets. It is considered by some authorities that the metal should contain a small amount of lead to facilitate rolling, but opinions differ as to the amount. American rollers limit the amount to 0.4 per cent. Generally, the amount must not exceed 1.25 per cent.

Metallic zinc, usually in the form of zinc shavings, but sometimes as zinc dust or "blue powder," is used for precipitating gold from cyanide solutions on most of the important goldfields. Blue powder is also in demand for reduction purposes in the preparation of synthetic dyes, and for the sherardizing of certain iron articles.

Zinc is used in the Parkes process of desilverizing lead—in the form of slabs, which are placed on the surface of the molten argentiferous lead. The melt is then well stirred and allowed to cool. The silver, gold, and copper contents of the lead combine with the zinc, forming a crust upon the surface of the melt. On removal, this crust is liquated to extract the lead and the resulting product distilled, thus saving a large proportion of the zinc and leaving an extremely rich silver-lead alloy from which the silver is extracted by cupellation.

Zinc alloys itself readily with copper, lead, iron and other metals. The numerous varieties of brass are alloys of different proportions of zinc and copper. The addition of a small amount of iron to the alloy produces a harder and tougher brass known commercially as delta metal. Nickel silver, or German silver, is an alloy of nickel, copper, and zinc, in varying proportions. The alloy is used as a substitute for silver in the manufacture of spoons, forks, &c. Many forms of antifriction metal containing zinc alloyed with copper, tin, antimony, or lead, or with a combination of these metals, are extensively used, particularly as linings for the bearings of high-speed engines.

Zinc forms important alloys with aluminium. The zinc rarely exceeds 10 to 20 per cent. of the alloy, but any combination of zinc and aluminium will form a solid solution as long as the zinc content remains below 40 per cent. During the war extensive use was made of aluminium alloys for the manufacture of aeroplane parts, shell fuses, and other articles where lightness combined with strength was desirable.

Zinc compounds, particularly zinc oxide, are much used in commerce. Zinc oxide, or zinc white, is largely used as a pigment, and as a filler in the rubber industry. Zinc sulphide precipitated with barium sulphate forms the pigment known as lithopone. Zinc chloride is a powerful dehydrant; it is used as a preservative of timber, and for vulcanizing paper fibre. Other compounds are used in medicine, and the soluble zinc sulphate is employed as a mordant in calico printing and for other purposes.

In addition to metallic zinc, by-products are obtained during the ordinary treatment of zinc sulphide ores. Sulphur, mainly in the form of sulphur dioxide, is given off during the preliminary roasting of sulphide ores and is used extensively for the manufacture of sulphuric acid, especially on the Continent and in America. Zinc dust or blue powder can be condensed in the "prolongs," and if sufficient care be taken in its collection this commands a higher price than the spelter.

Where the original ores contain substantial proportions of lead and silver, as is the case in Broken Hill concentrates and many other ores of complex composition, the spent retort residues (after extraction of the zinc) yield valuable by-products of these two subsidiary metals.

WORLD'S PRODUCTION.

Within the British Empire there are to be found some of the largest deposits of zinc ore in the world. Mention need only be made of the Broken Hill deposits of Australia, the Bawdwin mines of Burma, the Rhodesian Broken Hill, and the British Columbian zinc-lead-silver ores to show the great possibilities of the British Empire as a potential producer of spelter. Yet, prior to the war, these ample resources of raw material were little utilized by British and Colonial zinc manufacturers, and the production of spelter within the Empire was entirely confined to Great Britain and Australia. In England the furnaces were fed principally with calamines, imported chiefly from Spain, Algeria and Sardinia. With the exception of the Seaton Carew plant in Durham, no effort seems to have been made to meet the Empire requirements of spelter from Empire ores. At these works Broken Hill concentrates were (and are) treated by roasting and distillation, sulphuric acid being recovered as a by-product. The only other spelter plant in the Empire was at Port Pirie, where such concentrates were roasted and distilled.

In America the production of spelter was little more than sufficient to meet domestic demands, and the rest of the world's requirements of the metal were met chiefly by the German and Belgian smelters. Germany possessed considerable domestic resources of zinc ore, which were supplemented by large imports from abroad, but Belgian domestic resources were almost negligible. Practically the whole of the raw material required to supply the vast Belgian industry was drawn from abroad, largely from Australia through German merchants.

In Japan the position was similar to that in Belgium. Japanese smelters of zinc were almost entirely dependent upon outside sources for their supplies of raw material. Excluding America, and possibly Germany, the curious position obtained that the countries producing zinc ores were for the most part unable to treat them, while those equipped with the necessary smelters were lacking in domestic zinc ore deposits.

During the war great efforts were made to alter these conditions, and new modern smelting works were either erected or projected in Australia, India, Canada, Great Britain, and the U.S.A.; also in Japan, Norway, and Sweden; but very much yet remains to be done before the British Empire can be considered self-supporting in the matter of spelter production.

Prior to the war nearly the whole of the world's output of spelter was produced in the United States and Europe. In Europe the countries participating in the smelting industry were Belgium, Germany, Holland, the United Kingdom, Austria, France, Italy, Russia, Spain, and Norway; but the great bulk of the European spelter output was produced in Germany and Belgium, the other countries mentioned supplying comparatively small amounts. The European smelting industry was almost wholly controlled by the German Zinc Convention, a widespread organization for the control of production and selling prices.

The outbreak of war cut off from the Allied Powers the greater part of their normally available supplies of spelter. There was no shortage of zinc ore, but nearly all the smelting plants in Europe were situated either in Germany or in territory overrun by German troops.

The Allies were therefore compelled to turn to the United States as the only available source from which they could obtain the greatly increased quantities of zinc necessary for the equipment of their armies.

At that time there were in the United States many smelting plants operating below their full capacity. As soon as the demand for spelter forced up the price of zinc, the unused retorts were set to work and old abandoned smelters restarted. A period of unexampled prosperity set in for American producers. When it was realized that the war would last some years, great extensions were made to existing plants, and new smelters, many of modern design and immense capacity, were constructed in different parts of the country.

Similar activity was witnessed, although on a smaller scale, in Japan. Prior to the war the Japanese production of spelter was unimportant, but by the year 1918 Japanese capacity reached 60,000 tons of spelter per annum. In 1919, however, several of these plants were closed down.

In Great Britain considerable additions were made to the various smelter plants, and new works were built. The furnaces in use before the war were modified to adapt them for smelting complex ores, and the construction of a large smelting, refining, and by-product plant commenced at Avonmouth. It has been stated that these works when completed would raise the smelting capacity of Great Britain to 130,000 tons of spelter per annum, but their installation has since been suspended. During the period under consideration Canada constructed a successful electrolytic treatment plant at Trail, British Columbia, with a capacity of 15,000 tons of spelter per annum, and the small distilling plant at Port Pirie in Australia was extended. Mention should be made of a new electrolytic plant, with a capacity of 3,000 tons of zinc per annum, constructed at Risdon, in Tasmania, for the treatment of Australian zinc ores.

In America the Anaconda Company at Great Falls, Butte, Montana, erected a plant based on sulphuric acid leaching and subsequent electrolytic treatment of the zinc solutions, and designed to produce 35,000 tons of electrolytic zinc annually.

World's Production of Zinc (Smelter Production).

(In long tons.)

	1913.	1914.	1915.	1916.	1917.	1918.	1919.
United Kingdom*...	66,000	50,000	45,000	60,000	50,000	50,000	35,000
Canada	—	—	—	2,655	8,915	11,227	11,005
Australia	4,121	5,014	5,308	5,277	4,742	9,444	7,404
Austria	19,194	—	—	—	—	—	4,000*
Belgium	200,938	143,580	50,830	22,561	10,125	9,096	16,727
France	66,799	41,790	18,872	19,932	22,560	18,052	18,000*
Germany†	279,000	232,000	192,000	193,000	178,000	232,000	47,000*
Holland	23,940	16,193	10,954	11,910	3,995	670	—
Italy	—	—	—	254	361	1,169	1,261
Norway	9,138	18,695	24,598	31,486	21,646	—	3,400*
Poland (Russia) ...	10,331	6,199	1,968	1,082	—	—	2,500*
Spain	5,907	11,554	7,987	8,386	9,992	15,644	16,052
Sweden	2,081	2,263	8,450	9,836	7,851	4,032	2,283
United States ...	309,532	315,222	437,071	596,735	597,833	462,435	415,842
China (Exports) ...	893	305	2,291	762	425	127	107
Japan	—	5,807	20,754	38,297	53,741	39,203	22,000*

* Estimated.

† Figures given to nearest thousand tons.

Production of Zinc Ore and Spelter, and Consumption of Spelter in Leading Countries during 1913.

Country.	Zinc-Ore Production.	Spelter Production.	Consumption of Spelter.
	Long tons.	Long tons.	Long tons.
United Kingdom	17,294	66,000	191,473
Egypt	3,109	—	—
Canada	7,044	—	—
India	3,871	—	—
Australia	506,661	4,121	—
Austria... ..	33,675	19,194	43,293†
Belgium	934	200,938	75,172
France	45,828	66,799	79,698
Germany	627,066	278,563	228,567
Greece	35,817	—	—
Italy	155,734	—	10,725
Spain	115,937	5,907	5,805
Sweden... ..	49,936	2,081	—
Algeria	80,934	—	—
Tunis	28,167	—	—
United States	301,118*	309,532	308,265
Indo-China	32,893	—	—
China	9,397†	—	—
Japan	34,119	—	—

* Spelter from domestic ores.

† Exports only.

‡ Austria-Hungary.

BRITISH EMPIRE.

United Kingdom.*

The zinc ores mined in the United Kingdom are almost invariably blende associated with galena, which is frequently argentiferous. The ore occurs in veins traversing Palæozoic rocks, chiefly in North Wales, the North of England, the Isle of Man, and in Dumfries in Scotland.

At the commencement of the period under review the chief producing centres were the Nenthead and Nentsbury mines near Alston in Cumberland, the Wanlockhead mines in Dumfries, the Carshield mine in Northumberland, the Great Laxey mine in the Isle of Man, and the Halkyn and Rhosesmor mines in Flint.

In view of the considerable number of producing mines, the output of zinc ore has been small. With the exception of the Nenthead and Nentsbury mines, which yielded more than 7,000 tons of ore annually, and the Carshield mine, which produced 4,161 tons of ore in 1913, few mines yielded as much as 1,000 tons of ore annually. The total production of domestic ores for each year of the period under consideration is given in the accompanying tables.

The decline in output was due chiefly to the gradual closing down of the important Nenthead and Nentsbury mines in Cumberland, owned by the Vieille Montagne Zinc Company of Belgium, but the low prices obtainable for zinc ore and the high cost of production due to war conditions were causes that operated generally during the period, and rendered unprofitable the production of zinc ore other than that mined in conjunction with lead. Before the war, the whole of the zinc concentrates produced at the Vieille Montagne mines in Cumberland were shipped to Belgium for treatment.

Although Great Britain was among the pioneers of the zinc smelting industry, it remained remarkably unprogressive, small advantage being taken of modern experience

* Mines and Quarries: General Report with Statistics. Part III. By the Chief Inspector of Mines (Annual).

Annual Statements of the Trade of the United Kingdom.

Report by the Departmental Committee, appointed by the Board of Trade, to investigate and report upon the Non-Ferrous Mining Industry.

and improved methods, whilst Belgium, Germany and the United States made substantial progress. Formerly both Germany and Belgium possessed large resources in their domestic ore deposits. As the supply of easily smelted ores from these mines became exhausted, attention was directed to solving the problem of smelting the more complex sulphide ores and to the recovery of important by-products. With spelter about £20 to £25 per ton, success could only be obtained by improved smelting methods, and the recovery as by-products of the silver, lead, and sulphur in the ores, combined with lower fuel consumption and economy in labour. These problems were solved with such success that zinc smelting losses on complex ores were reduced by one-third to one-half, and substantial improvements were made in the design and equipment of by-product recovery plants. Before the war Germany and Belgium were able to supply over 80 per cent. of the spelter imported into the United Kingdom.

For the purposes of zinc extraction, it is necessary that the ore should be delivered at a reasonable price, and that fire-clay and coal should be readily obtainable. These conditions exist in Swansea, which has long been the chief centre of production in the United Kingdom.

The total consumption of spelter in the United Kingdom in the year 1913 did not exceed 192,000 tons, of which only about 30 per cent. was smelted in the country, and over 60 per cent. was imported from Belgium and Germany. The war brought about a large increase in the demand not only for ordinary spelter, but also for high-grade zinc, which was required in making munitions. The only country capable of meeting this demand in any considerable measure was the U.S.A., where there was keen competition for supplies. In consequence of this competition prices rose to a remarkable extent, and at one time during 1915, high-grade zinc sold at the record figure of £160 per ton.

Apart from the metal, the compounds of zinc are largely consumed in the United Kingdom. Of these compounds, zinc oxide is the most important. Prior to the war nearly 16,000 tons of this material were imported for consumption into the United Kingdom annually. The bulk of these shipments was obtained from the United States, Germany, Holland, Belgium, and France; very little was obtained from within the British Empire. During the war period, demands were met by greatly increased shipments from Holland and the United States.

New mills have been built for rolling zinc sheets and boiler plates; in addition to supplying the domestic demand, considerable quantities can be exported in future.

London has always been the principal market for European spelter. British spelter is sold as "good ordinary brand".

(G.O.B.), "virgin," and "special," the quality varying with the lead and iron contents. In good ordinary brands (G.O.B.) the lead usually averages about 0·8 to 1·8 per cent., and the iron from 0·02 to 0·04 per cent. "High-grade zinc," which is a special quality of the metal and is not included under spelter, should contain 99·9 per cent. of zinc. It is usually the electrolytic product. During the war a considerable amount of 99·9 per cent. zinc (sometimes 99·8 per cent.) was produced from spelter by the special redistillation methods of Fricker and others.

For some time before the war spelter was selling in London at £22 to £23 per ton. During the earlier years of the war, prices fluctuated violently. In January, 1915, spelter was sold at £28 per ton, in June of the same year the price rose to £120, by August the metal was quoted at £55, and in November the price again exceeded £100. In 1916 similar but less violent fluctuations were witnessed, but early in 1917 the great increase in American production, combined with stringent Government control, steadied the price at about £52 per ton, at which figure it remained fairly stationary during the remaining years of the war.

Production of Zinc Ore in the United Kingdom and the quantity of Zinc obtainable therefrom.

Year.	Zinc Ore. (Long tons.)	Amount of zinc obtainable by smelting. (Long tons.)	Value of Ore at Mines. (£)	Value of Metallic Zinc obtainable (£)
1913	17,294	5,823	69,502	132,255
1914	15,419	5,208	56,652	121,585
1915	12,057	4,096	70,383	273,135
1916	8,476	3,000	65,304	205,350
1917	7,484	2,735	76,694	142,699
1918	9,025	3,245	95,680	169,389
1919	6,933	2,436	62,202	102,951

Imports of Zinc Ore into the United Kingdom.

From		Quantity (long tons).							
		1913.	1914.	1915.	1916.	1917.	1918.	1919.	
Canada	...	990	415	139	39	—	30	5	
Australia	...	16,772	78,503	38,883	16,194	16,054	3,359	45,018	
Other British Possessions	...	210	121	1,523	639	188	—	33	
Total from British Possessions	...	17,972	79,039	40,545	16,872	16,242	3,389	45,056	
Belgium	...	483	524	—	—	—	—	—	
France	...	4,337	3,175	8,769	9,006	813	413	246	
Germany	...	7,169	5,190	—	—	—	—	—	
Italy	...	13,801	23,280	37,055	27,830	21,916	13,661	20,988	
Netherlands	...	987	1,711	917	714	25	—	10	
Russia	...	315	6,436	—	—	—	—	—	
Spain	...	6,348	6,474	10,509	8,403	15,705	39,596	7,214	
Algeria	...	9,302	6,929	2,465	7,140	27,411	24,066	1,464	
Tunis	...	1,378	1,866	—	2,783	4,232	6,673	1,181	
United States of America	...	7	470	1,690	112	73	—	15	
Japan (including Formosa and Japanese leased territories in China).	...	1,190	5,191	5,603	1,756	441	10	—	
Other Foreign Countries	...	1,381	3,966	6,807	3,709	510	4,979	2,378	
Total from Foreign Countries	...	46,698	65,212	73,815	61,453	71,126	89,398	33,496	
TOTAL	...	64,670	144,251	114,360	78,325	87,368	92,787	78,552	

Imports of Zinc Ore into the United Kingdom.

Value (£).							
Canada	10,949	3,921	1,768	722	—	981	176
Australia	83,892	411,586	281,585	164,151	161,587	33,630	484,313
Other British Possessions	1,730	1,073	9,199	7,799	4,764	—	555
Total from British Possessions	96,571	416,580	292,552	172,672	166,351	34,611	485,044
Belgium	3,984	3,447	—	—	—	—	—
France	28,875	20,362	138,918	168,624	14,744	7,981	3,900
Germany	58,227	39,938	—	—	—	—	—
Italy	106,826	152,706	485,552	372,043	302,302	181,963	215,324
Netherlands	8,071	14,760	15,901	18,949	650	—	192
Russia	1,443	36,737	—	—	—	—	—
Spain	27,162	29,295	78,458	101,562	118,116	349,657	52,757
Algeria	61,821	35,662	16,457	82,870	303,346	285,340	20,399
Tunis	5,513	7,720	—	30,150	41,631	57,274	12,884
United States of America...	79	3,542	49,655	1,528	936	—	940
Japan (including Formosa and Japanese leased territories in China).	10,020	44,380	53,418	32,097	5,288	110	—
Other Foreign Countries	9,036	11,874	82,753	60,446	11,575	57,767	44,115
Total from Foreign Countries	321,057	400,423	921,112	868,269	798,588	940,092	350,511
TOTAL	417,628	817,003	1,213,664	1,040,941	964,939	974,703	835,555

Imports of Zinc, Crude, in Cakes, into the United Kingdom.

From	Quantity (long tons).						
	1913.	1914.	1915.	1916.	1917.	1918.	1919.
Canada	962	1,319	1,420	1,326	194	815	8,034
Australia	186	216	3,647	1,330	439	—	739
New Zealand	81	98	63	21	17	—	1
Other British Possessions...	350	367	936	331	69	79	43
Total from British Possessions	1,579	2,000	6,066	3,008	719	894	8,817
Austria-Hungary	255	92	—	—	—	—	—
Belgium	53,500	27,312	—	—	—	4	2,818
France	5,915	3,183	1,965	591	83	9	886
Germany	64,179	33,491	—	—	—	—	473
Netherlands	13,301	12,189	12,930	3,674	2,693	15	3,505
Norway	719	987	3,794	1,178	3,246	5,591	2,375
United States of America	4,670	35,068	46,276	38,956	51,091	50,495	68,333
Japan (including Formosa and Japanese leased territories in China).	—	104	1,183	4,266	17,905	7,051	3,735
Other Foreign Countries	886	1,433	2,308	1,654	368	79	3,284
Total from Foreign Countries...	143,425	113,859	68,456	50,319	75,386	63,244	85,409
TOTAL	145,004	115,859	74,522	53,327	76,105	64,138	94,226

... Imports of Zinc, Crude, in Cakes, into the United Kingdom.

17

		Value (£).						
		18,514	25,526	92,023	107,837	13,335	35,363	392,089
Canada	...	3,084	3,783	232,514	99,516	25,106	—	39,183
Australia	...	1,496	1,980	2,670	1,478	692	—	21
New Zealand	...	7,002	6,442	46,944	21,494	3,004	2,542	7,957
Other British Possessions	...							
Total from British Possessions		30,096	37,731	374,151	230,325	42,137	37,905	439,250
Austria-Hungary		6,310	1,975	—	—	—	—	—
Belgium	...	1,291,011	615,538	—	—	—	145	116,461
France	...	144,921	69,876	90,521	39,195	2,688	143	31,802
Germany	...	1,503,023	730,441	—	—	—	—	19,049
Netherlands	...	320,091	284,691	656,304	255,031	148,567	615	132,196
Norway	...	20,515	28,733	309,017	110,748	196,681	379,344	102,507
United States of America	...	116,292	939,199	2,334,733	2,782,938	2,698,828	2,445,042	2,938,379
Japan (including Formosa and Japanese leased territories in China)	...	—	2,926	90,357	319,046	1,051,184	428,577	193,773
Other Foreign Countries	...	18,419	38,697	124,698	115,980	17,755	1,723	123,285
Total from Foreign Countries		3,420,582	2,712,076	3,605,630	3,622,938	4,115,703	3,255,589	3,657,452
TOTAL		3,450,678	2,749,807	3,979,781	3,853,263	4,157,840	3,293,494	4,096,702

Imports of Zinc Manufactures into the United Kingdom.

18

From		Quantity (long tons).							
		1913.	1914.	1915.	1916.	1917.	1918.	1919.	
Belgium	...	10,109	7,135	142	3	—	—	792	
France	...	368	357	1,219	208	176	274	60	
Germany	...	7,169	3,222	3	2	—	—	3	
Netherlands	...	1,062	1,083	1,466	1,620	1,444	70	808	
United States of America	...	48	634	4,936	1,717	2,100	2,010	2,787	
Other Foreign Countries	...	11	14	67	6	93	469	40	
Total from Foreign Countries	...	18,767	12,445	7,833	3,556	3,813	2,823	4,490	
Total from British Possessions	...	1	—	203	113	292	193	189	
TOTAL	...	18,768	12,445	8,036	3,669	4,105	3,016	4,679	
Value (£).									
Belgium	...	277,228	186,455	6,761	288	—	—	50,742	
France	...	13,538	11,576	68,150	15,163	16,613	22,538	2,866	
Germany	...	205,811	86,755	77	220	9	—	112	
Netherlands	...	29,765	35,504	71,649	149,568	133,892	7,432	51,277	
United States of America	...	2,633	27,338	273,355	182,044	208,688	213,683	210,422	
Other Foreign Countries	...	444	519	5,073	785	7,737	43,007	2,213	
Total from Foreign Countries	...	529,409	348,147	425,065	348,068	366,939	286,660	317,632	
Total from British Possessions	...	37	6	12,977	10,244	29,637	19,827	11,784	
TOTAL	...	529,446	348,153	438,042	358,312	396,576	306,487	329,416	

Imports of Zinc Oxide into the United Kingdom.

From		Quantity (long tons).							
		1913.	1914.	1915.	1916.	1917.	1918.	1919.	
Belgium	...	2,869	1,735	913	1,185	93	—	850	
France	...	750	1,193	1,562	831	262	—	42	
Germany	...	6,834	3,876	75	4	—	—	22	
Netherlands	...	2,104	2,609	4,179	4,681	2,905	75	1,331	
United States of America	...	5,826	8,159	11,837	6,972	6,694	3,804	4,179	
Other Foreign Countries	...	50	140	367	109	127	90	34	
Total from Foreign Countries	...	18,433	17,712	18,933	13,782	10,081	3,989	6,458	
Total from British Possessions	...	12	23	29	13	—	—	177	
TOTAL	...	18,445	17,735	18,962	13,795	10,081	3,989	6,635	
Value (£).									
Belgium	...	70,557	41,001	33,592	72,606	5,958	—	49,894	
France	...	19,953	30,971	50,204	49,690	24,291	1,473	3,028	
Germany	...	163,013	87,041	3,570	111	—	—	400	
Netherlands	...	49,763	62,086	146,776	251,342	190,430	7,708	86,622	
United States of America	...	124,621	185,535	333,051	284,296	375,190	222,639	227,021	
Other Foreign Countries	...	1,208	2,559	7,427	3,438	7,919	8,297	2,128	
Total from Foreign Countries	...	429,115	409,193	574,620	661,483	603,788	240,117	369,093	
Total from British Possessions	...	203	350	527	390	—	—	11,220	
TOTAL	...	429,318	409,543	575,147	661,873	603,788	240,117	380,313	

*Imports of Brass Wire into the United Kingdom.**

From	Quantity (long tons).						
	1913.	1914.	1915.	1916.	1917.	1918.	1919.
Total from British Possessions (Canada)	—	—	37	24	43	6	23
France	—	206	160	2	1	—	2
Germany	—	420	—	—	—	—	—
United States	—	222	2,859	1,079	771	292	88
Other Foreign Countries	—	40	2	—	17	27	—
Total from Foreign Countries	—	888	3,021	1,081	789	319	90
TOTAL	—	888	3,058	1,105	832	325	113
Value (£).							
Total from British Possessions (Canada)	—	—	4,874	3,732	10,078	1,448	4,121
France	—	14,823	15,429	479	458	—	1,043
Germany	—	34,228	—	—	—	—	—
United States	—	19,653	280,577	179,163	153,767	52,520	18,122
Other Foreign Countries	—	2,933	218	—	2,459	5,365	43
Total from Foreign Countries	—	71,637	296,224	179,642	156,684	57,885	19,208
TOTAL	—	71,637	301,098	183,374	166,762	59,333	23,329

* Not given separately prior to 1914.

Exports of Zinc Ore from the United Kingdom (Domestic Produce).

	To	Quantity (long tons).							
		1913.	1914.	1915.	1916.	1917.	1918.	1919.	
	Belgium	11,261	4,396	—	—	—	—	—	
	France	1,960	3,499	—	—	—	—	—	
	Netherlands	44	27	400	325	—	—	—	
	Other Foreign Countries	112	52	—	9	—	—	65	
	Total to Foreign Countries	13,377	7,974	400	334	—	—	65	
	Total to British Possessions	1	—	—	—	—	—	—	
	TOTAL	13,378	7,974	400	334	—	—	65	
Value (£).									
	Belgium	48,704	15,051	—	—	—	—	—	
	France	10,791	12,442	—	—	—	—	—	
	Netherlands	526	311	3,600	1,325	—	—	—	
	Other Foreign Countries	1,068	176	—	1,085	—	—	199	
	Total to Foreign Countries	61,089	27,980	3,600	2,410	—	—	199	
	Total to British Possessions	8	—	—	—	—	—	—	
	TOTAL	61,097	27,980	3,600	2,410	—	—	199	

Exports of Zinc or Spelter, Crude in Cakes, from the United Kingdom (Domestic Produce).

To	Quantity (long tons).							
	1913.	1914.	1915.	1916.	1917.	1918.	1919.	
Canada	143	90	5	—	—	—	—	
British India	3,859	1,350	345	21	17	221	2,691	
Other British Possessions	42	45	19	37	19	3	29	
Total to British Possessions...	4,044	1,485	369	58	36	224	2,720	
Belgium	—	—	—	—	—	—	232	
France	180	52	25	—	5	640	18	
Germany	1,475	1,125	—	—	—	—	—	
Netherlands	1,633	1,975	—	—	—	—	1,099	
Norway	3	21	—	915	5,296	—	2	
Russia	1,211	664	328	1,107	149	—	14	
Sweden	—	—	—	—	1,016	—	—	
Japan	526	305	—	—	—	—	717	
Other Foreign Countries	424	400	45	61	106	12	184	
Total to Foreign Countries	5,452	4,542	398	2,083	6,572	652	2,266	
TOTAL	9,496	6,027	767	2,141	6,608	876	4,986	

Exports of Zinc or Spelter, Crude in Cakes, from the United Kingdom (Domestic Produce).

		Value (£).						
Canada ...	...	3,269	1,894	500	—	—	—	17
British India ...	...	81,388	27,523	10,436	1,442	1,024	13,621	105,232
Other British Possessions ...	...	1,173	1,516	1,094	3,186	1,442	289	1,540
Total to British Possessions...	...	85,830	30,933	12,030	4,628	2,466	13,927	106,772
Belgium ...	...	—	—	—	—	—	—	12,616
France ...	...	5,899	1,766	1,613	—	300	35,840	859
Germany ...	...	31,223	21,749	—	—	—	—	—
Netherlands...	...	33,363	37,626	—	—	—	—	45,023
Norway ...	...	76	472	—	68,625	317,860	—	129
Russia ...	...	24,887	13,467	18,477	113,776	11,862	—	658
Sweden ...	...	—	—	—	—	60,899	—	—
Japan ...	...	18,560	9,843	—	—	—	—	29,303
Other Foreign Countries ...	...	8,275	7,808	2,361	5,091	6,561	1,022	8,229
Total to Foreign Countries...	...	122,283	92,731	22,451	187,492	397,482	36,862	96,817
TOTAL ...	...	208,113	123,664	34,481	192,120	399,948	50,789	203,589

TABLE 1.—IMPORTS OF GOODS FROM THE UNITED KINGDOM (CONSUMERS & EXPORTERS).

To	Quantity (long tons).							
	1913.	1914.	1915.	1916.	1917.	1918.	1919.	
Egypt	—	—	18	18	7	11	55	
British West Africa	—	—	24	23	10	8	33	
Hong Kong	51	54	107	96	61	11	36	
British India	494	292	419	469	265	187	370	
Straits Settlements and Dependencies (including Labuan).	—	—	77	43	26	24	49	
Australia	295	286	235	96	68	34	72	
New Zealand	45	56	63	27	11	13	19	
Other British Possessions	261	194	113	102	71	40	115	
Total to British Possessions...	1,146	882	1,056	874	519	328	749	
France	31	44	7	21	4	4	22	
Italy	4	2	6	226	163	116	217	
Netherlands	—	—	2	1	—	—	35	
Portugal	—	—	31	37	23	25	50	
Russia	26	27	165	103	389	—	4	
Turkey	—	—	—	—	—	—	(a) 47	
United States of America	1	—	—	—	—	—	—	
Argentine Republic	16	59	19	7	9	—	32	
Chile	—	—	27	40	19	11	42	
China (exclusive of Hong Kong, Macao and leased territories).	51	146	71	35	11	—	44	
Japan (including Formosa and Japanese leased territories in China).	95	73	36	6	1	—	72	
Other Foreign Countries	210	214	208	77	58	24	205	
Total to Foreign Countries	434	565	572	553	677	180	770	
TOTAL	1,580	1,447	1,628	1,427	1,196	508	1,519	

Exports of Manufactures of Zinc or Spelter from the United Kingdom (Domestic Produce).

		Value (£).						
Egypt	...	—	—	1,507	2,231	654	1,149	4,368
British West Africa	...	—	—	1,824	2,102	909	964	2,724
Hong Kong	...	1,806	1,829	7,107	8,759	4,500	812	2,343
British India	...	16,959	8,934	26,472	47,335	22,336	13,917	22,730
Straits Settlements and Dependencies (including Labuan)	...	—	—	4,053	4,901	2,044	1,908	3,430
Australia	...	9,951	9,858	15,407	10,777	5,717	3,323	5,660
New Zealand	...	2,540	2,145	5,447	3,532	978	1,001	2,074
Other British Possessions	...	10,479	7,480	9,266	12,621	8,145	4,069	10,612
Total to British Possessions	...	41,735	30,246	71,083	92,258	45,283	27,143	53,941
France	...	2,511	2,727	675	2,536	955	877	2,059
Italy	...	213	82	320	24,425	11,325	8,110	14,931
Netherlands	...	—	—	125	137	27	—	2,201
Portugal	...	—	—	2,137	4,486	2,234	1,799	3,521
Russia	...	815	995	9,247	7,643	25,548	—	278
Turkey	...	—	—	—	—	—	—	(a) 3,946
United States of America	...	67	—	—	—	—	—	—
Argentine Republic	...	713	2,542	1,685	914	1,327	16	4,145
Chile	...	—	—	2,382	3,912	1,730	911	2,988
China (exclusive of Hong Kong, Macão and leased territories)	...	2,078	3,781	4,683	3,780	943	54	3,660
Japan (including Formosa and Japanese leased territories in China)	...	2,794	2,251	2,338	710	100	—	3,323
Other Foreign Countries	...	9,650	8,042	16,443	9,559	5,412	2,477	17,606
Total to Foreign Countries	...	18,841	20,420	40,035	58,102	49,601	14,244	58,658
TOTAL	...	60,576	50,666	111,118	150,360	94,884	41,387	112,595

(a) Exported to ports or places in territory formerly Turkish but now occupied by other powers, e.g., Crete, Dedesgatch, Salonika, etc.

Exports of Zinc Oxide from the United Kingdom (Domestic Produce).

To	Quantity (long tons).						
	1913.	1914.	1915.	1916.	1917.	1918.	1919.
Egypt	—	—	20	43	19	14	45
Canada	406	240	118	60	1	1	5
British India	262	191	287	303	134	16	89
Straits Settlements and Dependencies (including Labuan).	30	17	30	30	31	6	18
Australia	117	122	294	303	17	7	17
Other British Possessions	211	159	151	148	66	34	100
Total to British Possessions...	1,026	729	900	887	268	78	274
France	81	39	218	465	136	26	409
Italy	—	—	3	18	10	—	124
Russia	—	6	152	178	28	—	—
Turkey	109	74	1	—	—	—	—
Brazil	120	86	457	652	303	6	177
Chile	339	185	75	128	95	4	42
Peru	108	85	10	16	39	—	2
Philippine Islands and Guam	26	27	70	8	4	—	10
Other Foreign Countries	681	706	354	372	110	49	270
Total to Foreign Countries	1,464	1,208	1,340	1,837	725	85	1,034
TOTAL	2,490	1,937	2,240	2,724	993	163	1,308

Exports of Zinc Oxide from the United Kingdom (Domestic Produce).

		Value (£).							
Egypt	...	—	—	930	1,840	1,365	1,193	3,316	
Canada	...	5,061	3,851	2,072	2,594	159	65	742	
British India	...	6,845	5,472	9,744	15,550	7,310	1,163	6,513	
Straits Settlements and Dependencies (including Labuan).	...	891	433	1,228	1,528	2,436	203	1,397	
Australia	...	3,524	3,605	11,176	17,415	1,029	632	1,627	
Other British Possessions	...	5,986	4,815	5,436	7,488	4,365	1,984	8,227	
Total to British Possessions...	...	22,307	18,176	30,586	46,415	16,664	5,240	21,822	
France	...	1,038	710	9,816	30,273	9,417	1,623	31,977	
Italy	...	—	—	146	1,315	640	—	8,443	
Russia	...	7	217	5,918	8,694	1,619	—	—	
Turkey	...	2,810	1,920	24	—	—	—	—	
Brazil	...	3,158	2,210	18,997	34,484	17,269	372	12,462	
Chile	...	7,503	3,952	2,095	5,842	5,027	267	2,662	
Peru	...	2,800	1,979	396	916	1,412	—	103	
Philippine Islands and Guam	...	907	1,102	2,595	395	383	—	684	
Other Foreign Countries	...	14,336	14,704	12,790	23,582	6,774	4,495	20,916	
Total to Foreign Countries	...	32,559	26,794	52,777	105,501	42,541	6,757	77,247	
TOTAL	...	54,866	44,970	83,363	151,916	59,205	11,997	99,069	

*Exports of Brass and Brass Manufactures, excluding Ordnance, from the
United Kingdom (Domestic Produce).†*

To	Quantity (long tons).					
	1914.	1915.	1916.	1917.	1918.	1919.
Egypt*	—	50	60	46	26	53
British West Africa ...	207	115	102	75	24	120
Union of South Africa...	444	342	474	228	184	260
British India	602	681	659	624	569	3,313
Straits Settlements and Dependencies (includ- ing Labuan)	135	106	124	85	39	80
Ceylon and Dependencies	83	70	84	77	28	34
Hong Kong	82	70	108	37	40	76
Australia	2,281	1,651	1,259	639	344	587
New Zealand	326	389	472	148	59	148
Canada	273	100	68	49	15	69
Other British Possessions	192	241	187	85	57	162
Total to British Pos- sessions	4,625	3,815	3,597	2,093	1,385	4,902
Russia	90	126	192	217	—	86
Sweden	97	38	15	1	—	56
Norway	150	67	36	35	7	181
Denmark (including Farøe Islands)	149	109	107	18	3	260
Netherlands	502	275	244	117	142	1,216
Germany	997	—	—	—	—	—
Belgium	227	—	—	—	—	325
France	1,075	4,796	5,471	1,671	1,595	1,242
Portugal	53	85	69	50	73	82
Spain	208	209	143	82	26	527
Italy	180	153	673	131	76	137
Egypt	56	—	—	—	—	—
China (exclusive of Hong Kong, Macão and leased territories) ...	98	64	101	65	44	172
Japan (including For- mosa and Japanese leased territories in China)	89	59	22	27	74	617
United States	291	168	83	40	38	724
Cuba	54	23	32	10	12	32
Chile	109	47	77	52	83	71
Brazil	231	85	113	112	34	117
Uruguay	35	73	31	14	19	36
Argentine Republic ...	389	190	167	88	67	259
Other Foreign Countries	308	353	378	115	43	390
Total to Foreign Countries	5,388	6,920	7,954	2,845	2,336	6,530
TOTAL	10,013	10,735	11,551	4,938	3,721	11,432

* Included in "Foreign Countries" prior to 1915.

† Not given separately prior to 1914.

*Exports of Brass and Brass Manufactures, excluding Ordnance,
from the United Kingdom (Domestic Produce).—continued.*

To	Value (£).					
	1914.	1915.	1916.	1917.	1918.	1919.
Egypt*	—	6,715	11,024	9,772	7,681	14,326
British West Africa ...	23,925	14,480	16,314	15,748	5,969	26,796
Union of South Africa...	58,668	44,833	84,232	40,822	42,406	71,409
British India	78,385	89,962	125,917	130,459	100,204	385,490
Straits Settlements and Dependences (includ- ing Labuan)	16,164	14,595	28,367	19,702	9,692	20,473
Ceylon and Dependencies	12,072	9,220	16,447	13,709	6,576	9,946
Hong Kong	10,752	9,839	19,109	7,309	9,484	19,098
Australia	288,167	217,960	243,823	110,635	73,818	146,348
New Zealand	59,421	59,234	83,088	26,152	13,514	42,560
Canada	33,915	14,098	15,539	9,124	5,938	13,566
Other British Possessions	24,349	31,343	35,222	20,003	15,158	36,154
Total to British Pos- sessions...	605,818	512,279	679,082	403,435	290,440	786,166
Russia—	11,768	18,603	38,845	38,092	102	14,764
Sweden	12,234	5,554	3,840	515	125	11,811
Norway	17,268	11,169	6,914	7,862	2,454	36,522
Denmark (including Farøe Islands)	18,422	14,718	21,201	5,133	987	47,436
Netherlands	60,414	40,899	48,533	30,374	39,090	186,374
Germany	76,625	—	—	—	—	—
Belgium	25,069	—	9	—	36	61,552
France	74,714	258,585	394,060	270,178	240,775	177,190
Portugal	6,401	11,652	11,433	10,878	15,203	16,424
Spain	24,782	26,124	22,996	14,656	5,049	84,189
Italy	18,075	18,382	64,790	18,147	13,235	26,920
Egypt	7,253	—	—	—	—	—
China (exclusive of Hong Kong, Macão and leased territories) ...	11,828	10,077	17,767	11,876	10,368	32,892
Japan (including For- mosa and Japanese leased territories in China)	12,674	7,573	4,383	6,528	12,997	57,167
United States	33,418	18,746	15,554	7,872	11,098	67,652
Cuba	5,248	3,108	4,698	2,268	2,698	9,812
Chile	12,389	5,939	12,684	10,918	17,825	21,722
Brazil	28,028	11,298	15,921	25,487	8,485	30,317
Uruguay	5,298	7,560	5,376	3,841	4,971	8,988
Argentine Republic ...	36,990	26,329	32,539	17,413	16,452	55,718
Other Foreign Countries	42,001	43,414	54,541	28,288	13,619	88,305
Total to Foreign Countries ...	540,899	539,630	776,084	511,326	415,563	1,035,855
TOTAL	1,146,717	1,051,909	1,455,166	914,761	706,009	1,822,021

* Included in "Foreign Countries" prior to 1918.

Exports of Galvanized Sheets (Flat or Corrugated) from the United Kingdom (Domestic Produce).

To	Quantity (long tons).						
	1913	1914	1915	1916	1917	1918	1919
Egypt **	—	—	1,971	1,839	135	117	795
Gold Coast	4,119	5,329	3,454	2,547	20	—	2,779
Nigeria	8,453	7,013	1,851	1,084	137	—	2,253
British South Africa ...	39,884	23,991	11,652	6,511	211	49	14,871
British East Africa ...	5,053	2,633	1,459	414	40	18	1,119
British India	237,673	104,830	64,059	9,707	1,496	742	41,506
Straits Settlements and Dependencies (including Labuan) ...	8,317	6,141	6,172	716	47	41	2,402
Ceylon and Dependencies	6,379	3,327	3,543	1,364	67	5	1,129
Australia	104,450	107,128	62,208	35,744	6,103	2,155	42,371
New Zealand	22,921	17,340	15,117	6,812	648	1,061	10,777
Canada	32,198	22,548	6,949	1,863	—	—	1,382
British West Indies ...	3,065	2,437	1,027	281	21	1	379
Other British Possessions	8,093	6,710	4,183	1,754	142	106	2,585
Total to British Possessions	480,605	409,427	183,645	70,636	9,067	4,295	124,348
Russia	11,107	10,647	1,617	117	—	—	757
Norway	4,226	4,095	2,168	1,256	4	—	2,306
Denmark (including Farøe Islands) ...	4,261	3,638	1,523	421	15	1	1,126
Netherlands	2,761	859	307	74	18	—	1,631
Java	18,166	17,732	7,847	3,913	480	8	1,450
Other Dutch Possessions in Indian Seas	9,389	8,129	4,147	895	228	—	1,044
Belgium	887	1,263	—	—	—	—	578
France	1,408	2,452	19,306	15,864	7,782	4,394	5,930
French West Africa ...	1,489	1,156	582	367	—	—	673
Germany	2,941	406	—	—	—	—	—
Portugal	3,836	3,944	2,103	951	23	—	1,019
Portuguese East Africa	7,569	4,726	2,086	1,279	16	1	1,909
Spain	3,033	2,795	3,209	1,988	112	2	2,194
Greece	2,122	2,195	1,675	563	5	22	525
Roumania	3,205	4,494	—	—	—	—	966
Turkey	3,411	2,125	*201	—	*113	*1	*259
Morocco	4,858	1,017	276	587	67	—	641
Siam	3,541	2,932	2,229	149	3	—	597
China (exclusive of Hong Kong, Macão and leased territories)	6,763	4,007	3,396	3,015	—	—	4,076
Japan (including Formosa and Japanese leased territories in China)	35,563	14,966	6,590	3,055	79	—	5,548
Philippine Islands and Guam	2,503	1,392	257	84	—	—	186
Cuba	2,521	961	211	2	—	—	61
Mexico	3,850	624	15	37	1	(a)	(a)
Costa Rica	1,317	1,118	11	5	—	(a)	(a)
Peru	2,068	945	363	178	—	—	242
Chile	15,674	5,954	1,785	1,239	—	2	1,312
Brazil	19,538	6,812	2,385	634	15	4	1,610
Uruguay	9,733	3,622	3,291	851	7	—	1,428
Argentine Republic ...	75,094	26,996	30,928	6,699	14	44	19,381
Other Foreign Countries	18,636	14,555	4,268	2,210	877	61	3,542
Total to Foreign Countries	281,470	156,557	102,776	46,433	9,869	4,540	61,591
TOTAL	762,075	565,984	286,421	117,069	18,926	8,835	185,939

* Exported to ports or places in territory formerly Turkish, but now occupied by other Powers. e.g., Crete, Dedeagatch, Salonika, etc.

** Included in "Foreign Countries" prior to 1915. (a) Included in "Other Foreign Countries."

Exports of Galvanized Sheets (Flat or Corrugated) from the United Kingdom (Domestic Produce)—continued.

To	Value (£).						
	1913	1914	1915	1916	1917	1918	1919
Egypt**	—	—	33,539	43,715	4,025	3,828	24,595
Gold Coast	51,881	67,956	55,910	62,655	575	—	83,770
Nigeria	117,505	89,655	26,437	28,457	3,945	8	72,777
British South Africa ...	554,647	279,351	173,194	161,354	5,146	1,775	459,427
British East Africa ...	62,304	31,215	23,270	10,698	1,175	449	32,435
British India	2,794,427	2,275,300	804,706	193,907	43,484	22,962	1,170,610
Straits Settlements and Dependencies (including Labuan) ...	113,959	85,237	98,988	18,368	1,483	1,153	79,531
Ceylon and Dependencies	82,031	40,253	56,564	31,076	1,874	146	34,091
Australia	1,583,475	1,649,121	1,349,005	1,161,435	247,353	71,704	1,611,419
New Zealand	338,371	256,399	309,463	201,489	25,426	37,193	395,010
Canada	470,359	314,052	120,696	28,951	—	—	45,753
British West Indies ..	41,404	30,962	16,843	6,881	806	46	11,377
Other British Possessions	109,137	85,648	66,249	45,808	3,422	3,280	83,835
Total to British Possessions	6,257,200	5,205,149	3,134,864	1,994,794	338,714	142,544	4,104,630
Russia	150,496	132,335	24,232	3,492	12	—	23,331
Norway	49,988	46,655	31,062	31,081	100	22	68,880
Denmark (including Farøe Islands) ...	54,800	43,930	21,405	9,829	445	30	34,526
Netherlands	34,348	11,276	3,921	1,481	545	—	48,944
Java	254,367	236,586	128,027	101,202	13,761	240	46,385
Other Dutch Possessions in Indian Seas	135,088	114,706	67,812	27,711	5,012	—	33,804
Belgium	11,951	17,258	—	—	—	—	21,000
France	17,794	30,881	272,483	346,001	158,621	119,723	170,938
French West Africa...	20,593	14,706	8,413	8,672	—	—	18,771
Germany	42,759	5,737	—	—	—	—	—
Portugal	49,362	48,316	30,881	21,903	646	—	31,178
Portuguese East Africa	93,473	54,426	31,066	27,329	466	29	55,757
Spain	41,617	35,929	51,680	52,770	3,397	46	74,136
Greece	27,215	27,543	24,350	15,911	200	723	17,931
Roumania	50,267	71,290	—	—	—	—	38,182
Turkey	45,177	26,849	*2,861	—	*3,695	*39	*8,679
Morocco	62,396	13,194	3,776	12,921	2,356	—	19,648
Siam	54,043	41,603	37,762	3,717	93	—	20,766
China (exclusive of Hong Kong, Macão and leased territories) ...	96,271	53,202	51,679	77,865	8	—	144,284
Japan (including Formosa and Japanese leased territories in China) ...	529,910	212,919	101,729	70,407	2,610	—	199,281
Philippine Islands and Guam	33,983	18,982	4,333	1,769	—	—	6,481
Cuba	32,525	12,269	3,013	62	—	—	2,303
Mexico	48,613	7,567	216	1,013	46	(a)	(a)
Costa Rica	17,545	14,316	226	120	—	(a)	(a)
Peru	25,236	10,746	5,730	4,414	—	—	7,251
Chile	184,432	67,147	26,714	31,598	—	40	37,339
Brazil	275,292	91,225	37,621	18,745	587	186	56,045
Uruguay	127,751	45,894	49,502	16,172	180	—	43,699
Argentine Republic ...	963,179	331,726	459,847	156,337	448	1,437	606,277
Other Foreign Countries	238,646	182,600	66,587	57,128	28,014	1,910	108,091
Total to Foreign Countries	3,769,117	2,021,813	1,546,978	1,099,650	221,242	124,425	1,943,907
TOTAL	10,026,317	7,226,962	4,681,842	3,094,444	559,956	266,969	6,048,537

* Exported to ports or places in territory formerly Turkish, but now occupied by other Powers, e.g., Crete, Dedeagatch, Salonika, etc.

** Included in "Foreign Countries" prior to 1915.

(a) Included in "Other Foreign Countries."

*Exports of Brass Wire from the United Kingdom (Domestic Produce).**

32

To.	Quantity (long tons).					Value (£).				
	1914.	1915.	1916.	1917.	1918.	1919.	1914.	1915.	1916.	1917.
Union of South Africa ...	64	35	23	5	—	3	6,507	4,288	4,169	1,777
British East Africa ...	106	3	1	—	—	—	8,146	404	129	67
British East Indies...	75	92	36	20	18	48	7,605	12,352	8,719	6,514
Australia ...	29	71	35	5	6	9	3,935	9,428	7,386	650
Other British Possessions ...	70	15	7	6	2	14	7,918	3,059	2,935	1,719
Total to British Possessions	344	216	102	36	26	74	3,411	29,531	23,338	10,727
Total to Foreign Countries ...	94	135	45	10	133	179	12,319	13,259	9,353	2,905
TOTAL	438	351	147	46	159	253	46,430	42,790	32,691	13,632
Union of South Africa ...	...	...	...	...	...	701	...	...	...	...
British East Africa ...	...	...	...	...	...	40	...	...	...	...
British East Indies...	...	...	...	...	...	9,113	...	...	...	...
Australia ...	...	...	...	...	...	1,649	...	...	...	...
Other British Possessions ...	...	...	...	...	...	2,810	...	...	...	...
Total to British Possessions	...	...	...	...	...	14,313	...	...	...	...
Total to Foreign Countries ...	...	...	...	...	...	28,857	...	...	...	...
TOTAL	...	...	...	...	...	43,170	...	...	...	...

* Not given separately prior to 1914.

Exports of Zinc Ore from the United Kingdom (Colonial and Foreign Produce).

33

30969

To		Quantity (long tons).							
		1913.	1914.	1915.	1916.	1917.	1918.	1919.	
Belgium	...	2,482	2,011	—	—	—	—	—	—
Germany	...	1,018	—	—	—	—	—	—	—
Netherlands*	...	—	—	18,371	16,317	—	—	—	250
Other Foreign Countries	...	2	—	981	—	5	—	—	—
Total to Foreign Countries	...	3,502	2,011	19,352	16,317	5	—	—	250
Total to British Possessions...	...	—	—	—	—	—	1	—	—
TOTAL	...	3,502	2,011	19,352	16,317	5	1	—	250
Value (£).									
Belgium	...	18,542	15,965	—	—	—	—	—	—
Germany	...	7,068	—	—	—	—	—	—	—
Netherlands*	...	—	—	138,657	122,052	—	—	—	2,200
Other Foreign Countries	...	20	—	9,251	—	30	—	—	—
Total to Foreign Countries	...	25,630	15,965	147,908	122,052	30	—	—	2,200
Total to British Possessions...	...	—	—	—	—	—	55	—	—
TOTAL	...	25,630	15,965	147,908	122,052	30	55	—	2,200

* Chiefly Broken Hill zinc concentrates.

B

Exports of Zinc, Crude in Cakes, from the United Kingdom (Colonial and Foreign Produce).

To	Quantity (long tons).							
	1913.	1914.	1915.	1916.	1917.	1918.	1919.	
Canada	930	497	—	—	—	—	—	
British India	—	45	1	—	—	105	215	
Australia	21	95	—	—	—	—	—	
New Zealand	75	154	25	50	—	—	—	
Other British Possessions	68	4	3	2	—	—	—	
Total to British Possessions...	1,094	795	29	52	—	105	215	
Belgium	—	—	—	—	—	—	436	
Denmark	80	—	—	—	—	—	—	
France	—	—	165	50	401	—	—	
Italy	188	30	—	—	—	—	—	
Netherlands	210	5	—	—	50	—	1,471	
Russia	1	2,194	709	766	151	—	1	
Japan	290	110	—	—	—	—	1,162	
United States of America...	176	150	—	—	—	—	—	
Other Foreign Countries	97	96	55	10	27	12	128	
Total to Foreign Countries	1,042	2,585	929	826	629	12	3,198	
TOTAL	2,136	3,380	958	878	629	117	3,413	

Exports of Zinc, Crude in Cakes, from the United Kingdom (Colonial and Foreign Produce).

		Value (£).						
Canada ...	...	19,982	10,744	—	—	—	—	—
British India ...	...	—	945	43	31	5,990	10,530	—
Australia ...	...	565	2,375	—	—	—	—	—
New Zealand ...	...	1,805	3,959	691	3,475	—	—	—
Other British Possessions ...	...	1,506	101	279	103	—	—	34
Total to British Possessions...	...	23,858	18,124	1,013	3,609	5,990	10,564	—
Belgium ...	...	—	—	—	—	—	16,697	—
Denmark ...	...	1,877	—	—	—	—	—	—
France ...	...	—	—	—	—	—	—	—
Italy ...	...	4,083	610	7,893	5,900	23,450	—	—
Netherlands ...	...	6,774	104	—	—	3,175	62,485	—
Russia ...	...	15	56,888	40,546	57,758	11,989	45	—
Japan ...	...	5,943	2,330	—	—	—	44,234	—
United States of America ...	...	3,704	3,130	—	—	—	—	—
Other Foreign Countries ...	...	2,299	2,227	3,509	644	1,671	722	5,296
Total to Foreign Countries ...	...	24,695	65,289	51,948	64,302	40,285	722	128,757
TOTAL ...	...	48,553	83,413	52,961	67,911	40,285	6,712	139,321

Exports of Zinc Manufactures from the United Kingdom (Colonial and Foreign Produce).

36

To		Quantity (long tons).							
		1913.	1914.	1915.	1916.	1917.	1918.	1919.	
Union of South Africa	...	7	—	—	—	—	—	—	—
British India	...	26	20	126	106	76	1	41	—
Australia	...	51	123	32	16	1	—	2	—
New Zealand	...	13	57	4	6	—	—	—	—
Other British Possessions	...	28	28	70	16	24	10	31	—
Total to British Possessions	...	125	228	232	144	101	11	74	—
Denmark	...	—	12	3	25	—	—	—	—
Norway	...	—	—	—	—	—	—	—	—
Russia	...	—	—	340	—	2	—	—	—
Portuguese East Africa	...	—	—	—	—	—	—	—	—
Brazil	...	14	—	—	—	—	—	—	—
Chile	...	24	—	—	—	—	—	—	—
Argentina Republic	...	27	3	18	—	1	—	2	—
China	...	—	—	—	32	—	—	—	—
Other Foreign Countries	...	117	95	90	22	23	1	65	—
Total to Foreign Countries	...	182	110	451	79	26	1	67	—
TOTAL	...	307	338	683	223	127	12	141	—

Exports of Zinc Manufactures from the United Kingdom (Colonial and Foreign Produce).

30969

Value (£).

Union of South Africa	...	...	...	322	—	—	8,121	—	9,873	—	6,794	—	173	—	—
British India	...	...	...	1,003	682	—	1,629	—	1,905	—	111	—	—	—	1,936
Australia	...	...	...	2,291	5,392	—	274	—	1,146	—	—	—	—	—	146
New Zealand	...	...	...	661	1,850	—	4,503	—	1,646	—	2,129	—	1,378	—	—
Other British Possessions	...	...	...	1,054	914	—	—	—	—	—	—	—	—	—	2,328
Total to British Possessions	...	...	...	5,331	8,838	—	14,527	—	14,570	—	9,034	—	1,551	—	4,410
Denmark	...	...	...	51	398	—	86	—	3,203	—	—	—	—	—	—
Norway	...	...	...	2	—	—	—	—	—	—	—	—	—	—	—
Russia	...	...	...	—	21	—	20,906	—	—	—	356	—	—	—	—
Portuguese East Africa	...	...	...	22	—	—	—	—	—	—	—	—	—	—	—
Brazil	...	...	...	481	—	—	—	—	—	—	—	—	—	—	—
Chile...	...	...	...	763	—	—	—	—	—	—	—	—	—	—	—
Argentine Republic	...	...	...	1,464	122	—	1,261	—	—	—	50	—	—	—	157
China	...	...	...	—	5	—	10	—	3,929	—	—	—	—	—	—
Other Foreign Countries	...	...	...	3,989	3,623	—	7,796	—	2,962	—	2,925	—	65	—	4,866
Total to Foreign Countries	...	...	...	6,772	4,169	—	30,059	—	10,094	—	3,331	—	65	—	5,023
TOTAL	...	...	...	12,103	13,007	—	44,586	—	24,664	—	12,365	—	1,616	—	9,433

Exports of Zinc Oxide from the United Kingdom (Colonial and Foreign Produce).

To	Quantity (long tons).							
	1913.	1914.	1915.	1916.	1917.	1918.	1919.	
Egypt*	—	—	1	60	7	1	2	
British India	—	5	55	26	69	1	—	
Australia	92	171	134	183	—	1	2	
Other British Possessions	4	17	11	26	9	2	19	
Total to British Possessions	96	193	201	295	85	5	23	
Denmark (including Farøe Islands)	—	—	130	42	—	—	—	
France	3	3	160	317	8	—	1	
Italy	—	—	—	—	40	—	6	
Russia	15	—	40	204	10	—	—	
United States of America	11	17	25	99	—	—	8	
Brazil	15	10	69	33	9	1	22	
Other Foreign Countries	78	89	114	39	87	—	31	
Total to Foreign Countries	122	119	538	734	154	1	68	
TOTAL	218	312	739	1,029	239	6	91	

* Included in "Other Foreign Countries" prior to 1915.

Exports of Zinc Oxide from the United Kingdom (Colonial and Foreign Produce).

Value (£).						
Egypt*	—	—	79	3,863	595	135
British India	—	116	2,216	1,822	4,583	146
Australia	2,504	4,845	5,760	10,755	29	41
Other British Possessions	106	602	434	1,684	675	141
Total to British Possessions	2,610	5,563	8,489	18,124	5,882	463
Denmark (including Farøe Islands)	—	—	4,400	2,617	—	—
France	—	95	8,965	18,241	739	—
Italy	—	—	—	—	2,700	—
Russia	419	3	1,166	15,007	974	—
United States of America	443	691	570	7,717	9	641
Brazil	445	287	3,064	2,483	683	1,533
Other Foreign Countries	1,893	2,235	4,494	2,484	4,977	2,205
Total to Foreign Countries	3,287	3,311	22,659	48,549	10,082	46
TOTAL	5,897	8,874	31,148	66,673	15,964	509
						6,733

* Included in "Other Foreign Countries" prior to 1915.

*Exports of Brass Wire from the United Kingdom (Colonial
and Foreign Produce).*

To	Quantity (long tons).						
	1913	1914	1915	1916	1917	1918	1919
Total to British Possessions	—	24	1	12	—	—	—
Total to Foreign Countries	—	4	1	2	1	—	2
TOTAL	—	28	2	14	1	—	2
	Value (£).						
	1913	1914	1915	1916	1917	1918	1919
Total to British Possessions	—	1,553	125	2,847	—	—	—
Total to Foreign Countries	—	450	227	492	320	—	239
TOTAL	—	2,003	352	3,339	320	—	239

*Average Prices of Spelter.**

Cents per lb.

Year				New York	St. Louis
1913	...	...	...	5·648	5·504
1914	...	...	...	5·213	5·061
1915	...	...	...	13·230	13·054
1916	...	...	...	12·804	12·634
1917	...	...	...	8·901	8·730
1918	...	...	...	8·159	7·890
1919	...	...	...	7·338	6·988

* *Eng. and Min. Journ.*, 11th Jan., 1919, and 17th Jan., 1920.

Average Prices of Spelter, Ordinary Brands, in London.
(In £ per ton.)

(Figures for 1913 and 1914 from the Metal Information Bureau; 1915-1919 official prices of the London Metal Exchange.)

Month.	1913.	1914.	1915.	1916.	1917.	1918.	1919.
January ...	£ s. d. 25 19 1	£ s. d. 21 6 6	£ s. d. 30 16 0 $\frac{1}{4}$	£ s. d. 83 12 4 $\frac{1}{2}$	£ s. d. 48 8 3 $\frac{1}{2}$	£ s. d. 52 0 0	£ s. d. 50 15 10 $\frac{1}{2}$
February ...	25 4 3	21 7 6	39 16 4 $\frac{1}{2}$	93 10 11	54 4 6	52 0 0	42 11 6
March ...	24 11 4	21 7 7	44 2 7 $\frac{1}{2}$	90 1 8 $\frac{2}{3}$	54 10 4 $\frac{1}{2}$	52 0 0	37 10 2 $\frac{1}{2}$
April ...	25 2 4	21 10 2	49 17 9	94 1 8	52 18 11 $\frac{7}{8}$	52 0 0	35 18 3
May ...	24 10 4	21 5 9	67 19 0	89 11 3 $\frac{1}{2}$	52 0 0	52 0 0	35 13 9
June ...	21 19 10	21 6 0	100 12 3 $\frac{1}{2}$	63 16 4 $\frac{1}{2}$	52 0 0	52 0 0	36 19 6
July ...	20 11 2	21 6 7	97 5 0	48 7 6	52 0 0	52 0 0	42 3 9 $\frac{1}{2}$
August ...	20 14 0	29 0 9	67 15 8 $\frac{1}{2}$	47 19 6 $\frac{1}{2}$	52 0 0	52 0 0	39 16 9
September ...	21 3 10	25 14 0	67 17 8 $\frac{1}{2}$	48 15 8 $\frac{1}{2}$	52 0 0	52 0 0	41 8 4 $\frac{1}{2}$
October ...	20 13 9	23 13 6	66 10 11 $\frac{1}{2}$	52 4 3 $\frac{1}{2}$	52 0 0	52 0 0	43 17 11 $\frac{2}{3}$
November ...	20 14 4	24 14 10	85 6 4 $\frac{1}{2}$	55 0 5 $\frac{1}{2}$	52 0 0	52 7 7 $\frac{1}{2}$	46 17 3
December ...	21 6 8	27 6 9 $\frac{1}{2}$	82 4 1 $\frac{1}{2}$	54 5 9 $\frac{1}{2}$	52 0 0	54 0 0	53 9 2 $\frac{1}{2}$

Rhodesia.

Zinc ores are known to occur in many districts of Southern Rhodesia, but so far no deposits of economic importance have been found.

In Northern Rhodesia an important deposit of lead-zinc ore is being developed in the Broken Hill District. The ore occurs in "kopjes" or small hills which are in some cases composed entirely of the oxidized ores of lead, zinc, and iron.

Formerly the bulk of the crude zinc consumed in Rhodesia was obtained from Germany and Belgium. These sources of supply were cut off during the war, and as very little crude zinc was obtainable from the United Kingdom, Rhodesia was practically dependent upon the United States for the necessary supplies.

The following table shows the imports of unmanufactured zinc into Southern Rhodesia during the period under review; the imports of zinc into Northern Rhodesia were unimportant, and never exceeded 50 cwt. in any one year.

*Imports of Unmanufactured Zinc into Southern Rhodesia.**

From	Quantity (long tons).						
	1913.	1914.	1915.	1916.	1917.	1918.	1919.
United Kingdom ...	12	2	—	2	8	—	1
Dominion of Canada	—	—	—	—	—	15	—
Commonwealth of Australia	—	—	—	—	—	35	74
Belgium ...	157	266	1	—	—	—	—
Germany ...	54	29	12	—	—	—	—
Holland ...	—	1	—	—	4	4	—
Sweden ...	3	2	—	—	—	—	—
United States ...	—	93	364	405	433	347	138
TOTAL ...	226	393	377	407	445	401	213
	Value (£).						
	1913.	1914.	1915.	1916.	1917.	1918.	1919.
United Kingdom ...	442	69	13	303	412	7	127
Dominion of Canada	—	—	—	—	—	1,345	—
Commonwealth of Australia	—	—	—	—	—	2,830	6,849
Belgium ...	4,670	7,264	12	—	—	—	—
France ...	—	—	21	—	—	—	—
Germany ...	1,607	827	312	17	—	—	—
Holland ...	—	30	—	—	478	459	—
Sweden ...	72	75	—	—	—	—	—
United States ...	—	3,807	19,759	43,651	41,016	33,332	13,172
TOTAL ...	6,791	12,072	20,117	43,971	41,906	37,973	20,148

* Annual Statement of the Trade and Shipping of the Union of South Africa and of Southern and Northern Rhodesia.

The Union of South Africa.

Zinc ores associated with those of lead have been reported to occur in several localities of the Union. In most cases very little work has been done towards proving the value of the deposits. The only production during the period under review was an output of 314 tons, valued at £2,214, in the year 1915, from the Transvaal.

The most important deposits are situated in the Malmani division, near Ottoshoop, in the western Transvaal, where the Buffelshoek, Witkop, and Bokkraal are the chief mines. In both the Witkop and Buffelshoek mines the ore occurs as pipes, penetrating dolomite, and only the outer portions of the pipes are mineralized. The inner parts are composed of brecciated dolomite cemented with calcite. Considerable development has been done and the ore proved to persist in depth. A modern concentrating plant, to treat the concentrates from both mines, was just completed when war broke out. Shortage of shipping and lack of smelting facilities in England made it impossible to dispose of the concentrates at a profit. Consequently, the mill was closed and not worked during the war period.

At the Bokkraal mine, in the Marico district, the ore occurs in fissures and impregnations in the dolomite. The ore minerals are zinc-blende and galena. Development had only reached the 50-foot level when war broke out, and all further development work was suspended.

Zinc ores have been reported as occurring in various parts of Natal, but the deposits have hitherto proved of small value. No zinc ores of any economic importance have been discovered in any of the other States of the Union.

Before the war more than 98 per cent. of the zinc consumed in the Union was imported from Belgium and Germany, and no zinc was shipped to the Union from either Australia or the United States. The outbreak of war found the Union of South Africa completely dependent upon European supplies. Successful efforts were made to meet the situation by imports from the United States, and to a lesser extent from Australia; but throughout the war period America provided more than 80 per cent. of the total zinc consumed.

No zinc-smelting or refining plants capable of re-smelting scrap zinc and sheets were in existence in South Africa prior to the war. The scrap metal was, therefore, shipped to the United Kingdom for treatment, and regular shipments continued to be forwarded throughout the whole war period.

*Imports of Unmanufactured Zinc into the Union of South Africa.**

From	Quantity (long tons.).						
	1913.	1914.	1915.	1916.	1917.	1918.	1919.
United Kingdom ...	49	44	30	35	26	14	21
Commonwealth of Australia	—	89	—	104	229	600	1,007
S. W. Africa Protectorate	—	—	—	—	—	5	—
Belgium ...	405	523	2	—	—	—	15
France ...	4	1	1	2	—	—	—
Germany ...	3,697	1,852	51	4	—	—	—
Holland ...	1	1	1	—	—	—	1
Norway ...	—	2	—	—	—	—	—
Japan ...	—	45	—	—	9	15	—
United States ...	—	1,841	3,214	4,204	2,789	2,436	1,121
TOTAL ...	4,156	4,398	3,299	4,349	3,053	3,070	2,165
	Value (£)						
United Kingdom ...	2,007	1,779	2,280	4,227	2,438	1,598	2,066
Commonwealth of Australia	—	2,700	—	13,336	19,777	51,990	83,806
S. W. Africa Protectorate	—	—	—	—	—	227	—
Belgium ...	12,462	13,996	62	—	2	—	940
France ...	224	52	52	306	57	55	—
Germany ...	113,841	50,362	1,654	154	5	—	—
Holland ...	43	42	92	19	42	—	36
Norway ...	—	45	—	—	—	—	—
Japan ...	—	1,547	—	—	570	1,410	9
United States ...	—	69,876	202,342	372,071	221,888	184,177	88,973
TOTAL ...	128,577	140,399	206,482	390,113	244,779	239,457	175,830

* Annual Statement of the Trade and Shipping of the Union of South Africa and of Southern and Northern Rhodesia.

Canada.*

The zinc-mining industry of Canada is centred in the provinces of British Columbia and Quebec.

The principal zinc-mining regions are situated in the Kootenay district of British Columbia, where there are large deposits of silver-lead-zinc ore. The chief producing mine is the Sullivan, in the Fort Steele division, where the ore worked is a replacement deposit of considerable size. The ore-body at this mine consists of a quartzite containing blende and argentiferous galena, and outcrops at a height of 4,800 feet above sea level. The deposit has a

* Annual Reports on the Mineral Production of Canada.
 Annual Reports of the Minister of Mines, British Columbia.
 Annual Reports on the Trade of Canada.

maximum stoping width of 120 feet, and a maximum stoping length of 325 feet as far as at present exploited. Other important districts are the Ainsworth, the Slocan and Slocan City, the Nelson and Arrow Lake divisions in West Kootenay, and the Omineca division in the Cariboo district.

Before the war there were no facilities for smelting zinc ores in Canada, and the whole production from Canadian mines was sent to the United States for treatment. Partly owing to the high lead content of the ore, but chiefly to the long freight haul, the United States duties, and other causes, the output was small, and the total tonnage exported for treatment did not exceed about 8,000 tons per annum.

During the war the great demand for high-grade zinc led the Canadian Government to investigate the possibility of utilizing the deposits of zinc ore in British Columbia and Quebec for the production of the zinc required for munitions. As a result of this work the electrolytic method of treating lead-zinc ores was successfully applied to British Columbian ores. By the autumn of 1915 three companies were producing zinc in Canada by the electrolytic process, and of these the plant of the Consolidated Mining and Smelting Company at Trail was by far the most important. The Trail smelter comprised lead and copper blast furnaces and copper and lead electrolytic refineries, and the company generated its own power hydro-electrically. During the war, zinc reduction works capable of producing 15,000 tons of electrolytic zinc per annum were added to the equipment of the plant.

The table given on page 46 shows the despatches of zinc from Canadian mines during the period under review. There can be little doubt that, apart from the high price obtainable for zinc during the war, the chief factor in the great expansion of the zinc-mining industry in Canada was the successful establishment of zinc-ore reduction works at Trail.

Of the total zinc-ore production of Canada about four-fifths was obtained from British Columbia, and the remainder, with the exception of small quantities from Alberta and other districts, from the province of Quebec. The only mines of any importance worked in Quebec during the period under review were the Notre Dame des Anges mines at Montauban, in the county of Portneuf, where there are two deposits of considerable value. The ore occurs chiefly as impregnations in quartzite and crystalline limestone. The chief ore minerals are ferruginous zinc-blende intimately associated with galena, and the ore carries gold and silver values. The average lead concentrates contain about 63 per cent. lead, 10 per cent. iron, and 8 per cent. zinc with 60 oz. of silver and $2\frac{1}{2}$ dwt. of gold per short ton. During the period under review considerable prospecting and development work was carried out on the newly discovered deposits of lead and zinc ore of the Gaspé Peninsula, particularly in the vicinity of the township of Lemieux. Two companies, the

Federal Zinc and Lead Company and the North America Mining Company, were operating in this district. The ore consists principally of zinc-blende and galena, and the oxidation products of those minerals.

A small experimental electrolytic zinc plant for the reduction of Quebec ores was erected at Welland, Ontario, but no zinc is reported as having been produced there during the period under review.

Prior to the war Canada imported the whole of the spelter required for domestic consumption from Germany, Belgium, the United States, the United Kingdom, and Holland. The war cut off European exports, but the supplies available in the United States, together with the yearly increasing production of zinc at Trail, were amply sufficient to meet Canadian needs.

Before the war nearly all the zinc dust consumed in Canada was obtained from the United States, Japan, Germany and Belgium. The great expansion of the Canadian metal industry during the period under review called for increasing quantities of zinc dust, the whole of which during the later years of the war was supplied by the United States and Japan.

Zinc oxide, known commercially as "zinc white," is used as a pigment, and is imported into Canada in large quantities. The United States, Belgium, Germany, Holland, Switzerland, Italy, France, and the United Kingdom all exported substantial quantities of this compound into Canada before the war. During the war European supplies were confined to fairly normal shipments from Holland and considerably reduced shipments (mainly re-exports) from the United Kingdom and Belgium; the balance required to meet the greatly increased Canadian demand was obtained almost wholly from the United States.

Annual Mine Despatches of Zinc Ores in Canada.

Year.	Zinc ore despatched.		Metallic zinc contained in ore.
	Quantity (long tons).	Spot Value* (£)	Quantity (long tons).
1913	7,044	38,922	3,156
1914	9,726	54,701	4,063
1915	13,299	115,612	5,460
1916	73,283	226,302	21,651
1917	104,008	275,830	28,864
1918	108,214	255,874	28,137
1919	119,306		26,078

* Values converted to £ sterling at the rate of 1 dollar = 4s. 2d.

Zinc Contents of Ore Produced in British Columbia.

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District.	Quantity (long tons).							
	1913.	1914.	1915.	1916.	1917.	1918.	1919.	
<i>East Kootenay—</i>								
Fort Steele	—	—	81	6,625	9,248	11,922	14,375	
Windermere Golden	—	—	139	94	8	—	—	
<i>West Kootenay—</i>								
Ainsworth	67	125	303	279	410	286	47	
Slocan and Slocan City	2,950	3,239	3,877	7,971	8,388	6,298	4,962	
Nelson and Arrow Lake	—	148	1,396	1,549	438	—	—	
<i>Boundary—Yale—</i>								
Yale, Ashcroft and Kamloops	—	—	—	—	12	—	—	
<i>Revelstoke Trout Lake and Lardeau</i>								
... ..	—	—	—	—	15	3	—	
<i>Cariboo—</i>								
Omineca	—	—	—	75	163	140	122	
TOTAL	3,017	3,512	5,796	16,593	18,682	18,649	19,506	

Zinc Contents of Ore Produced in British Columbia.

District.	Value (£).*						
	1913.	1914.	1915.	1916.	1917.	1918.	1919.
<i>East Kootenay—</i>							
Fort Steele	—	—	4,219	336,373	326,522	385,107	603,989
Windermere Golden	—	—	7,306	4,760	284	—	—
<i>West Kootenay—</i>							
Ainsworth	1,507	2,567	15,913	14,189	14,479	9,268	478
Slocan and Slocan City	66,081	66,499	203,545	404,699	296,171	203,974	130,203
Nelson and Arrow Lake	—	3,043	73,293	78,654	15,484	—	—
<i>Boundary—Yale—</i>							
Yale, Ashcroft and Kamloops	—	—	—	—	433	—	—
<i>Revelstoke Trout Lake and Lardreau</i>	—	—	—	—	525	91	—
<i>Cariboo—</i>							
Omineca	—	—	—	3,822	5,739	4,527	2,919
TOTAL	67,588	72,109	304,276	842,497	659,637	603,967	737,589

Note—The amount of the shipments has been obtained from certified returns received from the various mines, as provided for in the "Inspection of Metalliferous Mines Act, 1897,"
 In calculating the value of the products 85 per cent. of the average prices of zinc for the year in the New York Metal Market has been used as a basis.

Treatment and other charges have not been deducted.

* Values converted to £ sterling at the rate of 1 dollar=4s. 2d.

Imports of Zinc Blocks, Pigs, Bars, Rods, Sheets and Plates into Canada (Fiscal Years ending March 31).

From	Quantity (long tons.)							Value (£).*						
	1913.	1914.	1915.	1916.	1917.	1918.	1919.	1913.	1914.	1915.	1916.	1917.	1918.	1919.
United Kingdom	284	178	32	2	—	1	—	8,034	5,098	923	147	—	73	—
Bermuda	1	—	—	—	—	—	—	15	—	—	—	—	—	—
Newfoundland	—	—	—	1	—	—	—	1	—	1	7	1	—	—
Belgium	983	888	309	—	—	—	—	29,443	23,274	7,629	—	—	—	—
France	—	—	1	—	—	—	—	—	—	25	—	—	—	—
St. Pierre and Miquelon	1	—	—	—	—	1	—	9	—	—	—	—	12	—
Germany	2,367	516	242	—	—	—	—	64,989	12,928	5,982	—	—	—	—
Netherlands	109	—	—	—	—	—	—	3,228	—	—	—	—	—	—
United States	688	461	766	583	978	1,206	1,532	22,851	15,164	27,027	49,307	67,052	87,122	84,795
TOTAL	4,433	2,043	1,350	586	978	1,208	1,532	128,570	56,464	41,587	49,461	67,053	87,207	84,795
Total from British Empire	285	178	32	3	—	1	—	8,050	5,098	924	154	1	73	—
Total from Foreign Coun-tries	4,148	1,865	1,318	583	978	1,207	1,532	120,520	51,366	40,663	49,307	67,052	87,134	84,795

* Values converted to £ sterling at the rate of 1 dollar=4s. 2d.

Imports of Spelter into Canada (Fiscal Years ending March 31).

From	Quantity (long tons).							
	1913.	1914.	1915.	1916.	1917.	1918.	1919.	
United Kingdom	840	1,003	190	5	—	2	—	
Belgium	782	815	646	—	—	—	—	
Germany	290	432	366	—	—	—	—	
Netherlands	—	150	25	—	—	—	—	
Norway	—	40	—	—	—	—	—	
United States	2,903	2,800	4,537	6,394	6,159	7,302	4,066	
TOTAL	4,815	5,240	5,764	6,399	6,159	7,304	4,066	
Total from British Empire	840	1,003	190	5	—	2	—	
Total from Foreign Countries	3,975	4,237	5,574	6,394	6,159	7,302	4,066	
Value (£).*								
United Kingdom	23,108	23,066	4,199	507	—	63	—	
Belgium	21,330	18,682	15,009	—	—	—	—	
Germany	8,018	9,659	8,281	—	—	—	—	
Netherlands	—	3,179	560	—	—	—	—	
Norway	—	1,339	—	—	—	—	—	
United States	78,912	68,854	120,244	443,569	360,873	312,015	146,036	
TOTAL	131,368	124,779	148,293	444,076	360,873	312,078	146,036	
Total from British Empire	23,108	23,066	4,199	507	—	63	—	
Total from Foreign Countries	108,260	101,713	144,094	443,569	360,873	312,015.	146,036	

* Values converted to £ sterling at the rate of 1 dollar=4s. 2d.

Imports of other Manufactures of Zinc into Canada (Fiscal Years ending March 31).

From	Value (£).*						
	1913.	1914.	1915.	1916.	1917.	1918.	1919.
United Kingdom	490	449	491	27	121	65	75
Austria-Hungary	—	17	—	—	—	—	—
Belgium	60	—	379	7	—	—	—
France	47	133	2	—	—	—	—
Germany	38	66	10	—	—	—	—
Japan	—	—	—	—	—	2	—
United States	10,743	9,638	5,448	4,524	13,482	15,930	15,013
TOTAL...	11,378	10,303	6,330	4,558	13,603	15,997	15,088
Total from British Empire	490	449	491	27	121	65	75
Total from Foreign Countries	10,888	9,854	5,839	4,531	13,482	15,932	15,013

* Values converted to £ sterling at the rate of 1 dollar=4s. 2d.

Imports of Zinc Dust into Canada (Fiscal Years ending March 31).

	, From	Quantity (long tons).							
		1913.	1914.	1915.	1916.	1917.	1918.	1919.	
United Kingdom	...	—	—	7	—	—	—	—	
Belgium	...	—	6	5	—	—	—	—	
Germany	...	57	15	10	—	—	—	—	
Netherlands	...	5	—	—	—	—	—	—	
United States	...	63	138	154	254	197	147	154	
Japan	...	—	—	—	—	102	78	—	
TOTAL	...	125	159	176	254	299	225	154	
Total from British Empire	...	—	—	7	—	—	—	—	
Total from Foreign Countries	...	125	159	169	254	299	225	154	

Value (£).*

United Kingdom	...	—	12	364	5	—	—	—	
Belgium	...	—	143	119	—	—	—	—	
Germany	...	1,632	388	276	—	—	—	—	
Netherlands	...	136	—	—	—	—	—	—	
United States	...	2,079	4,155	7,221	19,059	22,239	11,496	9,797	
Japan	...	—	—	—	—	9,891	5,602	—	
TOTAL	...	3,847	4,698	7,980	19,064	32,130	17,098	9,797	
Total from British Empire	...	—	12	364	5	—	—	—	
Total from Foreign Countries	...	3,847	4,686	7,616	19,059	32,130	17,098	9,797	

* Values converted to £ sterling at the rate of 1 dollar=4s. 2d.

Imports of Sulphate and Chloride of Zinc into Canada (Fiscal Years ending March 31).

From	Quantity (long tons).							Value (£).*						
	1913.	1914.	1915.	1916.	1917.	1918.	1919.	1913.	1914.	1915.	1916.	1917.	1918.	1919.
United Kingdom	294	40	18	4	37	1	—	3,687	391	212	34	1,166	45	10
Belgium	30	37	18	—	—	—	—	377	287	114	—	—	—	—
France	—	1	—	—	—	—	—	—	5	—	—	—	—	—
Germany	10	43	8	—	—	—	—	191	356	57	—	—	—	—
United States	111	115	117	142	125	211	191	1,887	1,891	1,906	3,012	5,048	7,412	6,854
TOTAL	445	236	161	146	162	212	191	6,142	2,930	2,289	3,046	6,214	7,457	6,864
Total from British Empire	294	40	18	4	37	1	—	3,687	391	212	34	1,166	45	10
Total from Foreign Countries	151	196	143	142	125	211	191	2,455	2,539	2,077	3,012	5,048	7,412	6,854

* Values converted to £ sterling at the rate of 1 dollar = 4s. 2d.

Imports of Zinc White into Canada (Fiscal Years ending March 31).

From	Quantity (long tons).							
	1913.	1914.	1915.	1916.	1917.	1918.	1919.	
United Kingdom	983	1,293	641	363	307	1	1	
Newfoundland	—	—	—	—	—	—	—	
Belgium	414	837	271	—	3	—	—	
France	15	21	—	—	—	—	—	
Germany	985	1,105	627	—	—	—	—	
Italy ...	19	—	—	—	—	—	—	
Netherlands...	192	320	221	128	286	—	—	
Spain...	—	—	—	—	22	—	—	
Switzerland	46	—	—	—	—	—	—	
United States	2,290	1,978	2,638	4,897	5,903	6,864	7,432	
Total from Foreign Countries	3,961	4,261.	3,757	5,025	6,214	6,864	7,432	
TOTAL	4,944	5,554	4,398	5,388	6,521	6,865	7,433	

Imports of Zinc White into Canada (Fiscal Years ending March 31).

Value (£).*						
United Kingdom	...	...	...	18,781	9,810	7,623
Newfoundland	...	...	...	—	—	1
Belgium	...	...	...	14,275	3,970	—
France	...	...	...	430	—	—
Germany	...	...	...	22,062	10,472	—
Italy	...	...	...	—	—	—
Netherlands	...	...	...	5,786	3,628	3,062
Spain...	...	...	...	—	—	—
Switzerland	...	...	...	—	—	—
United States	...	...	...	43,428	59,670	161,515
						257,195
						290,165
Total from Foreign Countries	...			85,981	77,740	164,578
						257,195
						290,165
TOTAL	...	...	...	104,762	87,550	172,201
						257,346
						290,315

* Values converted to £ sterling at the rate of 1 dollar = 4s. 2d.

India.*

No metallic zinc was produced within the Indian Empire during the period under review. Zinc-lead ores are known to exist in various localities, but the only large deposits worked are those at Bawdwin, in Burma.

The silver-lead and zinc ore deposits at the Bawdwin mine are remarkable for their size and richness and for the high silver values contained in the sulphide ore.

The ore channel, cutting across a formation of rhyolitic tuffs of pre-Cambrian age, is an extremely faulted zone fully 8,000 feet in length and with a width of 400-500 feet. Within this zone three important ore-bodies are known, only two of which are at present opened up, namely, the western or Burman ore-body, containing a thin silver-lead and zinc ore vein, and a large replacement deposit known as the Chinaman lode, at least 1,200 feet in length with a width varying from a few feet to over 100 feet. The second ore-body, known as the Central or Shan lode, lies parallel with the Burman and carries copper as well as silver-lead and zinc ore. Very little is known concerning the third ore-body, which has not yet been explored. Close geological examination suggests that ore-bodies may reasonably be expected to exist throughout the whole length of 8,000 feet and as far to the south as the rhyolitic tuffs extend. There are also indications that further exploration in a northerly direction might expose important bodies of copper ore.

Before the year 1912, work was concentrated on smelting at Mandalay the slags containing lead and zinc formerly rejected by the Chinese miners who worked for silver alone. These smelters were removed in 1912 from Mandalay to Nam Tu, where the present modern concentrating mill, lead-smelting plant, and reduction works were erected during the period under review. During this period operations at the mine were mainly confined to exploration and the work of opening up the great Chinaman lode discovered in 1913. By the year 1915 the upper parts of this ore-body were prepared for stoping. The output of the mines was necessarily restricted pending the completion of the large reduction works at Nam Tu, but in 1918, 19,074 tons of metallic lead and 1,970,000 oz. of refined silver were produced.

It is not intended to reduce the zinc concentrates in Burma. At the present time large quantities are stored for future reduction at Jamshedpur, India, awaiting the erection of a

* Records of the Geological Survey of India.

Annual Statement of the Sea-borne Trade of British India.

Imports of Zinc or Spelter into India (Fiscal Years ending March 31).

From	Quantity (long tons).						Value (£).					
	1914.	1915.	1916.	1917.	1918.	1919.	1914.	1915.	1916.	1917.	1918.	1919.
United Kingdom ...	4,591	1,508	549	613	264	161	126,715	43,794	36,387	63,064	23,461	12,466
Aden and Dependencies ...	13	4	17	5	5	—	234	102	900	303	288	8
Ceylon ...	35	41	54	62	17	4	803	976	2,768	3,493	761	226
Hong Kong ...	—	—	—	—	—	99	—	—	3	—	—	494
Straits Settlements (including Labuan) ...	—	12	3	138	121	22	9	261	83	6,289	10,841	1,024
Mauritius and Dependencies ...	10	3	5	5	1	—	210	53	209	252	53	—
Zanzibar and Pemba ...	7	6	7	5	1	—	144	100	293	243	126	—
East Africa Protectorate ...	2	2	7	1	11	—	49	47	317	64	445	—
Australian Commonwealth ...	—	—	—	35	—	1,312	—	—	—	1,880	—	88,335
Other British Possessions ...	—	1	1	2	2	1	7	11	23	62	72	39
Total from British Empire ...	4,658	1,577	643	866	422	1,599	128,161	45,344	40,983	75,650	36,049	102,592
Holland ...	—	—	11	9	7	—	—	58	821	768	860	—
Germany ...	1,089	296	13	—	—	—	32,685	8,643	343	—	—	—
Belgium ...	966	233	28	—	—	—	29,347	6,732	788	—	—	—
Asiatic Turkey, Persian Gulf ...	—	—	2	2	3	2	3	4	80	98	105	82
Mascat Territory and Trucial Oman ...	2	1	5	—	—	—	32	22	242	10	8	3
Japan ...	—	—	7	452	2,960	3,005	—	63	539	32,508	172,119	196,584
German East Africa ...	17	7	—	—	—	1	354	163	—	—	—	38
United States of America ...	1	100	81	81	138	72	56	3,925	5,084	8,482	14,974	8,174
Other Foreign Countries ...	6	4	1	5	2	1	141	96	32	195	95	32
Total from Foreign Countries	2,081	642	148	549	3,110	3,081	62,618	19,706	7,929	42,061	188,161	204,913
TOTAL ...	6,739	2,219	791	1,415	3,532	4,680	190,779	65,050	48,912	117,711	224,210	307,505

plant designed to produce 10,000 tons of spelter and 32,000 tons of sulphuric acid per annum. The manufacture of sulphuric acid in India from the waste sulphur dioxide of the Bawdwin ores is a development which will have far reaching effects on India's metallurgical and chemical progress.

Prior to the war considerable quantities of zinc concentrates from the Burma mines were shipped to Belgium and Germany for treatment, and trial quantities were sent to the United Kingdom and Australia. The crude zinc to meet domestic requirements was obtained almost entirely from the United Kingdom, while supplies of manufactured zinc were drawn from the United Kingdom, Germany, and especially Belgium. The outbreak of war found India almost wholly dependent upon the United Kingdom for the zinc required for domestic consumption—a position the Japanese were quick to grasp. During the war Japan made great efforts to expand her zinc smelting and refining resources. These efforts proved so successful that during the fiscal year 1916-1917 Japan imported from Burma nearly 3,000 tons of zinc concentrates and exported to India during the following year nearly 3,000 tons of crude and manufactured zinc

Exports of Zinc Ore from India (Domestic Produce)*

(Fiscal Years ending March 31).

To	Quantity (long tons.).					
	1914.	1915.	1916.	1917.	1918.	1919.
Total to British Empire.	327	31	181	217	—	—
Total to Foreign Countries.	7,333	4,878	6	2,997	2	—
TOTAL	7,660	4,909	187	3,214	2	—
	Value (£).					
	1914.	1915.	1916.	1917.	1918.	1919.
Total to British Empire.	1,334	276	3,545	1,012	—	—
Total to Foreign Countries.	30,462	22,793	220	14,918	10	—
TOTAL	31,796	23,069	3,765	15,930	10	—

* Practically the whole of this material was obtained from the Bawdwin mine.

Exports of Zinc or Spelter from India (Foreign Produce)
(Fiscal Years ending March 31).

To	Quantity (long tons).					
	1914.	1915.	1916.	1917.	1918.	1919.
Total to British Empire.	39	67	329	97	3	2
Total to Foreign Countries.	36	20	1	4	4	1
TOTAL	75	87	330	101	7	3
	Value (£).					
Total to British Empire.	898	712	14,093	2,998	294	294
Total to Foreign Countries.	836	529	20	208	224	53
TOTAL	1,734	1,241	14,113	3,206	518	347

Australia.*

Most of the zinc ore produced in Australia has been obtained from the Broken Hill district, New South Wales, where zinc-blende forms one of the chief constituents of a large body of sulphide ore. Tasmania has important deposits. Occurrences of zinc ore are known in Queensland, but no production is recorded. Western Australia produces only a few tons of concentrates yearly.

The Broken Hill mines are situated in the Barrier region of New South Wales, and extend along the Barrier ridge for a distance of nearly two miles. The ore consists of a complex mixture of argentiferous galena and blende in a gangue of rhodonite, quartz, and garnet, together with some iron-pyrites and copper-pyrites.

The ore-bodies assume the form of a mineralized cap with divergent branches dipping steeply on either side. The downward extension of these branches is chiefly confined to the eastern side, where the ore is now being mined at a considerable depth. During the early years of mining on these fields only galena was recovered, the blende product being dumped as unsaleable. Improved concentrating and smelting methods have made it possible to treat these enormous accumulations, which have yielded during the period under review a considerable addition to the total output of zinc ore from the Broken Hill district.

* Annual Reports of the Department of Mines, New South Wales. Annual Reports of the Secretary for Mines, Tasmania. Trade and Customs and Excise Revenue of the Commonwealth of Australia (Annual).

The following figures taken from the Annual Reports of the Department of Mines, New South Wales, show the quantity of zinc concentrates produced in New South Wales during the years 1913-1919 inclusive :—

Production of Zinc Concentrates in New South Wales.

Year.				Quantity (long tons).	Value (£).
1913	...	...	...	506,661	1,547,987
1914	...	...	...	359,310	1,020,711
1915	...	...	...	190,916	1,111,569
1916	...	...	...	209,741	961,849
1917	...	...	...	113,531	441,486
1918	...	...	...	87,019	295,413
1919	...	...	...	72,294	247,395

Before the war most of the zinc concentrates produced at Broken Hill were shipped to Germany and Belgium for treatment under long term contracts entered into with the ore dealers. Less than 20,000 tons per annum was shipped to England to be smelted at the Sulphide Corporation plants at Seaton Carew and at other works, and only about 2½ per cent. of the concentrates produced was smelted in Australia at Port Pirie.

The control exercised over the output of the Broken Hill mines by the Zinc Convention proved a source of great embarrassment to the Australian Commonwealth at the outbreak of war. The furnaces operating in Great Britain designed to smelt Broken Hill ores were inadequate to deal with the large quantities of Australian ore rendered available by the cancellation of the Zinc Convention contracts, while the small smelting plant at Port Pirie was quite unable to affect the situation.

The position in which the Australian zinc industry was placed was both anomalous and exasperating, for never had the demand for zinc been more persistent or prices higher; yet Australian mines, though capable of supplying the whole requirements of the United Kingdom, were compelled to shut down because nowhere within the British Empire were there adequate facilities for smelting Australian ores. Unable to sell large quantities of zinc ore in Europe, Australian producers turned to the United States and Japan for markets, but throughout the war period the total yearly exports of zinc concentrates from Australia never exceeded 41 per cent. of the pre-war shipments.

In order to safeguard the zinc resources of Australia in the future, the Australian Government dealt drastically with the situation. All existing contracts with the Zinc Convention were cancelled, and a company was formed under the name of the Zinc Producers Association Proprietary, Limited, to control the whole of the zinc concentrates produced in Australia. A contract was entered into with the British Government, by which the latter guarantees to take 45,000 tons of spelter per annum

Production of Silver, Lead, and Zinc from Ores Mined in New South Wales.

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Year.	Metal produced in Australia.				Concentrates exported.					Total value of product.
	Silver.	Lead.	Spelter.	Value.	Quantity.	Contents by average assay.			Value of concentrates.	
						Silver.	Lead.	Zinc.*		
	Fine oz.	Long tons.	Long tons.	£	Long tons.	Fine oz.	Long tons.	Long tons.	£	£
1913	5,908,638	106,432	4,121	2,709,867	547,388	8,596,251	117,903	184,149	3,759,691	6,469,558
1914	5,481,286	99,925	5,014	2,592,322	431,965	7,879,240	88,173	146,400	3,004,248	5,596,570
1915	5,302,199	101,090	5,308	3,267,736	159,784	1,710,058	9,819	71,049	1,051,849	4,319,585
1916	6,382,518	128,438	5,277	5,238,276	170,687	1,725,374	16,428	69,141	1,139,607	6,377,383
1917	7,562,286	138,006	4,694	5,765,094	94,586	983,693	6,181	43,912	668,934	6,434,028
1918	8,724,018	155,306	5,622	6,744,034	48,494	535,943	3,178	21,926	232,210	6,976,244
1919	5,886,947	80,175	7,119†	4,109,466†	38,740	417,871	2,425	18,146	263,751	4,363,217†

* Zinc contents only ascertained where payment is made for same, i.e., not in lead concentrates.

† Includes 169 tons of Zinc Oxide, valued at £8,112.

produced in the Commonwealth, and a minimum of 250,000 tons of concentrates over a period of ten years. Measures were also taken for modernizing and enlarging the Port Pirie smelting works and installing electrolytic reduction plant.

Prior to the war the price of spelter ranged from £26 3s. 4d in 1912 to £21 in 1914. The heavy demand for zinc throughout the world, combined with shortage of shipping, forced up prices during the two following years to the very high average of £68 19s. 7d. in 1915 and £71 18s. 6d. in 1916; but increased American and Japanese production brought down the price to £54 in 1917.

The exports of zinc ore and concentrates, crude zinc, zinc rods, bars, and sheets are shown in detail in the accompanying tables for each year of the period under review. Apart from 25 tons, 22 tons and 2 tons of zinc ore exported to the United Kingdom in 1915-16, 1916-17, and 1917-18 respectively, all the exports have been in the form of concentrates.

In Tasmania there is an extensive mineral belt on the west coast, chiefly in the Read-Rosebery district, where important zinc-lead sulphide deposits have been found at intervals over a length of 7 miles.

The more important ore-bodies are replacement deposits in calcareous schists of Silurian and pre-Silurian age. The chief ore minerals are zinc-blende, galena, and pyrite, with accessory chalcopyrite, tetrahedrite, and pyrargyrite. Gold and silver are always present, chemically associated with certain of the mineral constituents.

Under the impulse of war conditions, attention was directed to the exploitation of these deposits on a considerable scale, but lack of adequate capital has greatly delayed the satisfactory establishment of a zinc-mining industry commensurate with the potential resources of the district.

Zinc-blende occurs in the South Heemskirk tin-fields associated with the tin ores of the district. In places the zinc-blende forms the bulk of the ore, but little work has been done to prove the extent of these deposits.

In the Zeehan silver-lead district zinc-blende occurs abundantly, chiefly along the Silver King—Zeehan Bell line of lodes, and has been worked in many of the mines on this belt.

The erection of an electrolytic zinc-reduction plant at Risdon was an event of considerable importance to Tasmania. The works are operated by hydro-electric power, and were designed primarily for the reduction of Broken Hill concentrates. When working to full capacity, the plant is capable of producing from 3,000 to 4,000 tons of zinc annually.

Production of Zinc in Tasmania.

Year.	Quantity (long tons).	Value (£).
1917	48	1,968
1918	3,822	152,880
1919	285	13,110

Exports of Zinc Concentrates from the Commonwealth of Australia (Domestic Produce) (Fiscal Years ending June 30).

To	Quantity (long tons).				
	1914-15.	1915-16.	1916-17.	1917-18.	1918-19.
United Kingdom ...	20,228	18,771	42,467	5,469	37,478
Union of South Africa ...	—	70	1	—	20
Canada ...	—	3,205	10,883	—	—
Belgium†... ..	47,544	—	—	—	—
France	5,598	14,105	—	—	—
Germany	6,970	—	—	—	34,349
Japan	—	37,760	71,819	45,200	—
Netherlands	3,200	—	—	—	—
United States	36,950	110,519	35,260	5,907	—
Total to British Possessions ...	20,228	22,046	53,351	5,469	37,498
Total to Foreign Countries ...	100,262	162,384	107,079	51,107	34,349
TOTAL ...	120,490	184,430	160,430	56,576	71,847

Exports of Zinc Bars, Blocks and Rods (Spelter) from the Commonwealth of Australia (Domestic Produce) (Fiscal Years ending June 30).

To	Quantity (long tons).				
	1914-15.	1915-16.	1916-17.	1917-18.	1918-19.
United Kingdom ...	2,224	1,456	1,011	—	—
India	—	—	35	150	1,162
New Zealand	—	11	19	30	56
Pacific, Fiji and Ocean Islands	—	1	—	—	—
Union of South Africa ...	—	2	—	—	—
Other British Countries	4	—	—	—	—
France	—	300	601	—	—
Japan	450	130	—	—	300
Russia	—	400	500	—	—
Total to British Possessions ...	2,228	1,470	1,065	180	1,218
Total to Foreign Countries... ..	450	830	1,101	—	300
TOTAL ...	2,678	2,300	2,166	180	1,518

† A portion of this reached Germany.

* In addition to these exports, 48 tons and 539 tons of zinc sheet were exported to New Zealand and the Union of South Africa respectively in the fiscal year 1917-18, and in the year 1918-19 1,280 tons was exported to South Africa and 14 tons to other countries.

New Zealand.*

Zinc ores are found at many localities in New Zealand, notably in the Thames, Coromandel, and Collingwood districts. Zinc-blende is frequently associated with many of the gold-bearing lodes, but as no production of zinc ore was recorded during the period under review it would seem that such zinc ore as was raised during gold-mining operations did not prove sufficiently valuable to be worth saving.

Imports of Plain Sheets of Zinc into New Zealand.

From	Quantity (long tons).						
	1913.	1914.	1915.	1916.	1917.	1918.	1919.
United Kingdom ...	56	40	20	16	4	1	
Canada ...	—	—	—	6	—	—	
Australia ...	1	4	2	—	—	46	
Belgium ...	163	166	—	—	—	—	
France ...	—	—	15	—	—	—	
Germany ...	56	27	—	—	—	—	
Netherlands ...	—	—	—	2	15	—	
Sweden ...	—	1	—	—	—	—	
United States ...	1	15	119	140	97	37	
TOTAL ...	277	253	156	164	116	84	
	Value (£).						
	1913.	1914.	1915.	1916.	1917.	1918.	1919.
United Kingdom ...	1,673	1,220	1,337	1,831	349	103	
Canada ...	—	—	—	658	—	—	
Australia ...	23	241	100	26	—	4,855	
Belgium ...	4,731	4,521	—	—	—	—	
France ...	16	—	759	—	—	—	
Germany ...	1,714	745	—	—	—	—	
Netherlands ...	8	—	—	205	1,226	—	
Sweden ...	—	13	—	—	—	—	
United States ...	19	660	6,166	16,892	10,168	4,193	
TOTAL ...	8,184	7,400	8,362	19,612	11,743	9,151	

* Statistics of the Dominion of New Zealand: Volume II. Trade and Shipping (Annual).

Imports of Perforated or Cellular Zinc Sheets into New Zealand.

From	Quantity (long tons).						
	1913.	1914.	1915.	1916.	1917.	1918.	1919.
United Kingdom ...	31	30	8	7	2	—	
Canada ...	—	—	—	—	—	—	
Australia ...	1	1	—	—	—	—	
Austria ...	—	1	—	—	—	—	
Germany ...	3	—	—	—	—	—	
United States ...	1	—	1	—	2	7	
TOTAL ...	36	32	9	7	4	7	
	Value (£).						
	1913.	1914.	1915.	1916.	1917.	1918.	1919.
United Kingdom ...	1,376	1,131	797	1,035	447	10	
Canada ...	—	—	—	26	—	—	
Australia ...	48	31	21	3	—	4	
Austria ...	—	109	—	—	—	—	
Germany ...	240	7	—	—	—	—	
United States ...	89	—	84	64	282	94	
TOTAL ...	1,753	1,278	902	1,128	729	108	

Imports of Zinc (Bar and Spelter) into New Zealand.

From	Quantity (long tons).						
	1913.	1914.	1915.	1916.	1917.	1918.	1919.
United Kingdom ...	14	5	25	1	—	—	
Australia ...	10	24	16	16	14	57	
Belgium ...	310	118	1	—	—	—	
Germany ...	2	2	—	—	—	—	
Netherlands ...	—	121	50	50	—	—	
TOTAL ...	336	270	92	67	14	57	
	Value (£).						
	1913.	1914.	1915.	1916.	1917.	1918.	1919.
United Kingdom ...	414	129	824	114	3	5	
Australia ...	309	606	885	966	841	3,410	
Belgium ...	8,244	2,734	13	—	—	—	
Germany ...	58	50	—	—	—	—	
Netherlands ...	—	3,712	1,509	3,053	—	—	
TOTAL ...	9,025	7,231	3,231	4,133	844	3,415	

Exports of Zinc (Bar and Spelter) from New Zealand.

To	Quantity (long tons).						
	1913.	1914.	1915.	1916.	1917.	1918.	1919.
United Kingdom ...	10	110	47	34	—	—	
Australia	—	2	—	—	—	—	
TOTAL	10	112	47	34	—	—	
	Value (£).						
	1913.	1914.	1915.	1916.	1917.	1918.	1919.
United Kingdom ...	99	1,984	1,556	1,674	—	—	
Australia	—	45	—	—	—	—	
TOTAL	99	2,029	1,556	1,674	—	—	

NOTE.—New Zealand also re-exported to Australia, during 1914, 3·5 tons of Bar and Spelter valued at £200, and in 1918, 20 tons valued at £720.

FOREIGN COUNTRIES.

Austria-Hungary.

The lead-zinc ore deposits of chief importance in Austria are those of Carinthia, notably those at Bleiberg-Kreuth, Kreuzen, Obir, Petzen, and Miess; but the zinc-ore production appears to have diminished in recent years.

Exports of Zinc Ore from Austria-Hungary.

Year.	Quantity (long tons).					
1913	...	...	...	...	...	16,114
1914	...	...	...	...	...	9,668
1915	...	...	...	...	...	3,779
1916	...	...	...	...	...	1,596
1917	...	...	...	...	...	2,642
1918	...	...	...	...	...	
1919	...	...	...	...	...	

Belgium.*

For many years past there has been a steady decline in the quantity of zinc ore mined in Belgium. The more important mining areas are the Vieille Montagne mines in Moresnet, and those situated near Verviers, Bleyberg, and Liège. Belgium, however, possessed prior to the war smelting and refining plants of the first magnitude, and contributed about 40 per cent. of the

* Annales des Mines de Belgique. Statistique des Industries Extractives et Métallurgiques.

total European production of spelter. The greater number of the Belgian smelting companies were under the control of the Zinc Convention already referred to. They obtained their supplies of ore and sold their products through the metal merchants who were members of that Convention.

Belgian supplies of ore were drawn from nearly all the zinc producing countries of the world, particularly from Australia. Belgian furnaces before the war smelted about 75 per cent. of the total Australian production of zinc ore. One-third of the total imports of zinc ore into Belgium were smelted at the works of the Vieille Montagne Company, one of the largest producers of spelter and zinc products in the world.

Production of Zinc Ore in Belgium.

Year.	Quantity (long tons).	Value* (£).
1913	934	3,508
1914	403	1,152
1915	783	3,256
1916	592	3,532
1917	227	1,368
1918	17	106
1919		

Production of Spelter and Rolled Zinc in Belgium.

Year.	Spelter.		Rolled Zinc.	
	Quantity (long tons).	Value* (£).	Quantity (long tons).	Value* (£).
1913	200,938	4,621,788	50,662	1,300,678
1914	143,580	3,111,274	30,285	740,204
1915	50,830	1,352,522	21,007	635,454
1916	22,561	740,428	7,916	291,066
1917	10,125	340,712	1,648	68,380
1918	9,096	426,274	733	44,500
1919	19,364	1,181,530	20,963	1,626,824

France.†

The French production of zinc ores from domestic sources has fallen considerably in recent years. Important deposits of zinc-blende and its oxidation products are worked at Malines in the department of Gard, and there are considerable deposits of argenteriferous sulphide and calamine in the Pyrenees. Zinc-blende is also worked in the Bormettes mine, department of Var. A considerable proportion of the spelter produced in France is obtained from ores, mostly calamines, mined in Algeria and

* Values converted to £ sterling at the rate of 25 francs = £1.

† Statistique de l'Industrie Minérale en France et en Algérie. (Annual.)

Tunis. Fortunately the chief smelteries and refining works in France were situated at Noyelles-Godault and Viviez, well away from the area of military operations. Those lying in the battle area in the north, notably St. Amand and Auby, were destroyed, but the German-owned works at Mortagne, near Givet, were left uninjured.

During the war considerable extensions were made to existing smelting works, and an entirely new plant was erected near Marseilles to treat Algerian and Tunisian ores.

Production of Argentiferous Zinc-Lead Ore in France.

Year.	Ore (long tons).	Quantity of metal contained in the Ore.		
		Zinc. (long tons).	Lead (long tons).	Silver (kilograms).
1913	45,828			
1914	45,317	5,993	4,380	7,273
1915	23,396	2,910	1,494	2,177
1916	33,744	4,863	2,160	3,057
1917	37,512	5,278	2,249	3,815
1918	24,684	6,497	4,610	5,359
1919				

Production of Zinc in France.

Year.	Quantity (long tons).				
1913	...	...	...	...	66,799
1914	...	...	...	...	41,790
1915	...	...	...	...	18,872
1916	...	...	...	...	19,932
1917	...	...	...	...	22,560
1918	...	...	...	...	18,052
1919	...	...	...	...	18,000*

French Imports and Exports of Zinc.

Year.	IMPORTS.		EXPORTS.	
	Quantity (long tons).	Value† (£).	Quantity (long tons).	Value† (£).
1913	39,354	905,120	29,255	719,160
1914	30,158	690,400	13,331	330,240
1915	36,233	278,328	4,554	376,800
1916	63,614	7,236,800	4,021	470,880
1917	72,314	7,347,480	4,097	430,960
1918	45,624	4,644,760	3,067	320,960
1919				

* Estimated.

† Values converted to £ sterling at the rate of 25 francs = £1.

Germany.

Before the war Germany produced nearly 42 per cent. of the total European production of spelter, or about 28·4 per cent. of the world's supply.

Silesia has long been the chief producing province, with Tarnowitz as the centre of the mining industry. The ore minerals are calamine and zinc-blende, associated with cerussite and galena, occurring as replacement deposits in limestone and dolomites. Other localities where important zinc-mining operations are carried on are Westphalia and the Rhine districts. In addition to the large supplies of domestic ore, Germany imported in the year 1913 approximately 308,000 tons of zinc ore from foreign countries. Importation during the war period was stopped, but Germany found no difficulty in supplying the increased demand for spelter and high-grade zinc for munition purposes from domestic resources. The principal smelting centres are situated in Silesia, Rhenish Prussia, Westphalia, and north-west Germany. The Silesian furnaces depend chiefly on local ore, and the west German smelters largely on imported concentrates.

Production of Zinc in Germany.

Year.						Quantity (long tons).
1913	...	...	...	...	...	279,000
1914	...	...	...	...	...	232,000
1915	...	...	...	...	...	192,000
1916	...	...	...	...	...	193,000
1917	...	...	...	...	...	178,000
1918	...	...	...	...	...	232,000
1919	...	...	...	...	...	47,000*

Production of Zinc Ore in Prussia.

Year.				Quantity (long tons).	Value† (£).
1913	...	...	...	639,253	2,199,519
1914	...	...	...	559,710	1,888,660
1915	...	...	...	514,236	2,360,596
1916	...	...	...	551,635	3,024,709
1917	...	...	...	553,056	3,253,673
1918	...	...	...	480,787	3,449,540
1919	...	...	...	308,311	3,898,501

Greece.‡

Greece is a considerable exporter of zinc concentrates. The principal mining areas are situated at Laurion at the extreme south of the Boeotian Peninsula, and in the Islands of Thasos, Siphos and Antiparos. Both in the archipelago and on the main-

* Estimated.

† Values converted to £ sterling at the rate of 20 marks = £1.

‡ Tableaux Statistiques du Mouvement Minier de la Grèce (Annual).

land the ores occur as veins and pockets in metamorphosed dolomites and schists. Low-grade calamine and blende are the principal ore minerals; these are usually associated with argentiferous galena, siderite, and manganese ore. Production remained fairly constant until the year 1917, when the output fell considerably.

Production and Sales of Zinc Ore in Greece.

Year.	Production (long tons).	Sales.	
		Quantity (long tons).	Value* (£).
1913	35,817	3,316	3,905
1914	31,919	3,276	2,866
1915	32,589	3,589	6,438
1916	25,438	1,791	3,093
1917	14,060	1,313	4,586
1918	4,273	24	61
1919			

NOTE.—The Zinc content of the ore varied from 23 to 33 per cent.

Italy.†

Ores of lead and zinc are found in many parts of Lombardy and Tuscany on the mainland, and at Iglesias in the island of Sardinia. In Tuscany the more important zinc-mining districts are situated near Serravezza, where the ore is found in quartz veins cutting Palæozoic rocks. The ore minerals are argentiferous galena, boulangerite, jamesonite, zinc-blende, and chalcopyrite, in a gangue of quartz, calcite, and siderite. In Lombardy, zinc-mining activity is centred in the Bergamasque Alps, where before the war the English Crown Spelter Company and the Vieille Montagne Company were operating on sulphide and calamine ores. The important district of Iglesias in the island of Sardinia produces more than five times the combined tonnage of all the other zinc-producing areas of Italy. The ore occurs in veins traversing schists and quartzites of Cambrian and pre-Cambrian age, the ore minerals being argentiferous galena, calamine, blende, and iron pyrites. A small amount of manganese is present in the ore. The output from the Sardinian zinc mines fell nearly 50 per cent. during the period 1913-1917.

Very little zinc is smelted in Italy. Only one small smelter at Vado Ligure was operated during the period under review. It has been stated that there are in Piedmont and Sardinia ample

* Values converted to £ sterling at the rate of 25 francs = £1.

† Rivista del Servizio Minerario (Annual).

supplies of sulphide ore suitable for electrolytic treatment. Investigations carried out during the war period show that Italy could be made self-supporting in the matter of spelter by the erection of a sufficient number of electrolytic reduction plants.

Production of Zinc Ore in Italy.

Year.	Production (long tons).			Value* (£).
1913	...	...	155,734	747,518
1914	...	...	143,569	560,247
1915	...	...	79,326	436,320
1916	...	...	92,532	698,303
1917	...	...	78,176	775,735
1918	...	...	66,037	727,277
1919	...	...	64,574	676,294

NOTE.—Zinc content of ore approximately 40 per cent.

Production of Crude Zinc and Zinc Oxide in Italy.

Year.	Crude Zinc.		Zinc Oxide.	
	Quantity (long tons).	Value* (£).	Quantity (long tons).	Value* (£).
1913	—	—	—	—
1914	—	—	—	—
1915	—	—	—	—
1916	254	23,902	1,512	31,264
1917	361	42,452	1,566	95,502
1918	1,169	155,815	1,334	127,913
1919	1,261	117,244	859	75,079

Imports of Zinc into Italy.

Year.	Zinc, Plates and Sheets.		Zinc, Ingots and Scrap.		Other Manufactures of Zinc.	
	Quantity (long tons)	Value* (£).	Quantity (long tons)	Value* (£).	Quantity (long tons)	Value* (£).
1913	5,683	161,720	12,248	298,762	291	18,497
1914	3,694	106,605	10,349	256,649	244	15,054
1915	991	28,593	12,637	313,379	79	4,550
1916	921	153,422	17,480	2,060,833	81	13,380
1917	947	173,160	18,125	2,063,141	91	17,209
1918	536	98,082	10,040	1,142,814	95	18,117
1919						

* Values converted to £ sterling at the rate of 25 lire=£1.

Exports of Zinc from Italy.

Year.	Zinc, Plates and Sheets.		Zinc, Ingots and Scrap.		Other Manufacture of Zinc.	
	Quantity (long tons)	Value* (£).	Quantity (long tons)	Value* (£).	Quantity (long tons)	Value* (£).
1913	74	2,103	1,541	37,591	28	1,343
1914	23	653	1,214	30,102	31	1,478
1915	7	210	85	2,106	17	976
1916	10	1,673	127	14,964	12	1,945
1917	5	980	13	1,485	10	2,304
1918	8	1,580	5	557	9	2,136
1919						

Norway.†

Ores of zinc and lead are found in various districts in Norway, but there are no mines working on a large scale. There are extensive bodies of low-grade zinc ores in Hakedal and Nannestad, near Christiania, and lead and zinc mines at Mo, in the Nordeland district. At Sarpsborg an electrothermic zinc reduction plant, with a capacity of 10,000 tons per annum, operated during the period. The output from the works consisted mainly of refined zinc produced from spelter of common grade imported from other countries.

Production of Zinc Ore in Norway.

Year.	Production (long tons).			Value‡ (£).
1913	...	...	883	1,022
1914	...	...	239	269
1915	...	...	1,800	3,441
1916	...	...	1,001	1,774
1917	...	...	265	538
1918	...	...	...	...
1919	...	...	...	...

NOTE.—The average Zinc content of the ore is about 22 per cent.

Production of Zinc in Norway.

Year.	Quantity (long tons)				
1913	...	...	...	...	9,138
1914	...	...	...	...	18,695
1915	...	...	...	...	24,598
1916	...	...	...	...	31,486
1917	...	...	...	...	21,646
1918	...	...	...	...	...
1919	...	...	...	...	3,400§

* Values converted to £ sterling at the rate of 25 lire=£1.

† Norges Bergverksdrift (Annual).

‡ Values converted to £ sterling at the rate of Kroner 18·6=£1.

§ Estimated.

Russia.

The zinc-mining areas situated in the Kielce district of Poland have provided the larger proportion of the zinc produced in European Russia. Formerly calamine was the principal mineral mined, but these deposits have been nearly exhausted, and mining operations are now confined to the lower-grade sulphide ore.

The most important zinc-producing areas are situated in the Altai mountains in Siberia, where the Ridder mine has been operated by the Irtysh Corporation. The ore mined is a complex mixture averaging about 18 per cent. of lead and 31 per cent. of zinc, with varying quantities of copper, silver, and gold. Concentrating plants capable of treating 200,000 tons of ore yearly were under construction during the period under review. The smelting works are situated a few miles away on the Ekibastus coalfield, where the first of the twenty proposed distilling furnaces commenced operations in 1916.

Other important deposits of zinc ore occur north of Vladivostock on the Tiutihe River. Before the war a large amount of German capital was invested in prospecting and developing several of the zinc-silver mines of this district, a railway 30 miles in length was under construction, and other important works were projected. During the war all work was stopped, and the property sequestered by order of the Russian Government.

Production of Zinc in Russia.

Year.						Quantity (long tons).
1913	...	...	...	...	...	10,331
1914	...	...	...	...	...	6,199
1915	...	...	...	...	...	1,968
1916	...	...	...	...	...	1,082
1917	...	...	...	...	...	
1918	...	...	...	...	...	
1919	...	...	...	...	...	2,500*

Spain.†

Spain possesses important deposits of zinc-lead and lead-zinc silver ores. The principal zinc-mining regions are situated on the southern coast of the province of Murcia, where the ores worked are mainly blende and galena, and in the province of Santander where there are large deposits of zinc ore, mostly calamine, associated with a small proportion of lead and copper ores and occasionally cinnabar. The ore occurs chiefly in pockets in the Carboniferous Limestone of the Cantabrian Mountains. In the vicinity of the ore these limestones are extensively dolomitized.

Other important deposits of zinc ore are found in the Cretaceous limestones of Biscay and Guipúzcoa, and in the

* Estimated.

† Estadística Minera de España (Annual).

Pyrenees, where many mining companies are working the rich argentiferous galena and zinc-blende lodes of the district.

Spain continued to produce both zinc ore and spelter throughout the war period. Production of ore on the whole declined but the manufacture of zinc increased considerably. The leading zinc works are those of Penarroya and Arnas in the provinces of Cordoba and Oviedo.

Production of Zinc Ore and Spelter in Spain.

Year.	Zinc ore Quantity (long tons).			Spelter Quantity (long tons).
1913	...	...	...	115,937
1914	...	...	...	112,480
1915	...	...	...	80,605
1916	...	...	...	163,384
1917	...	...	...	121,856
1918	...	...	...	105,239
1919	...	...	...	101,943
				5,907
				11,554
				7,987
				8,386
				9,992
				15,644
				16,052

Sweden.*

The larger proportion of the zinc ores produced in Sweden is obtained from the Vieille Montagne Company's mines at Ammeberg at the northern end of Lake Wetter in Gothland. The ore occurs as lenses and impregnations of blende and galena associated with iron pyrites, in schistose gneiss. Zinc ores are worked on a small scale in other districts in Sweden and Finland, but the production from these sources is unimportant.

Before the war nearly all the zinc ores shipped were exported to Belgium for treatment, but during later years there has been an increasing application of hydro-electric power for the electric reduction of zinc ores.

Production of Zinc Ore and Spelter in Sweden.

Year.	Zinc ore. Quantity (long tons).			Spelter. Quantity (long tons).
1913	...	...	...	49,936
1914	...	...	...	41,600
1915	...	...	...	55,038
1916	...	...	...	59,724
1917	...	...	...	50,487
1918	...	...	...	47,727
1919	...	...	...	48,656
				2,081
				2,263
				8,450
				9,836
				7,851
				4,032
				2,283

Algeria.†

Ores of zinc and lead are found at numerous localities in northern Algeria from the frontier of Morocco to the Tunisian border.

* Bergshantering Berattelse av Kommerskollegium (Annual).

† Statistique de l'Industrie Minérale en France et en Algérie (Annual).

The chief zinc-mining region is situated in the department of Constantine, where the ore occurs mainly as replacement deposits in Cretaceous limestones. The ore mined consists of calamine and blende together with argentiferous galena.

The most important mines are the Hammam N'Bails and the Ain Arko in the department of Constantine, and there are many localities in the Atlas mountains from which considerable quantities of zinc ore have been obtained. Prior to the war most of the zinc ore produced in Algeria was smelted in Germany, France and Belgium, but during the war a reduction plant designed to treat Algerian ore was erected at Marseilles.

Algerian Production and Exports of Zinc Ore.

Year.	Production. Quantity (long tons).			Exports. Quantity (long tons).
1913	...	...	...	80,934
1914	...	...	...	79,685
1915	...	...	...	41,092
1916	...	...	...	19,245
1917	...	...	...	37,430
1918	...	...	...	41,725
1919	...	...	...	17,652
				28,817
				4,193

Tunis.*

Ores of zinc and lead occur in Tunis in similar geological formations to those of Algeria; and although there are no mines of outstanding importance there are a large number of mineralized areas yielding lead and zinc. The ores mined consist chiefly of calamine and galena, together with a little blende and cerussite.

Production of Zinc Ore in Tunis.

Year.	Quantity (long tons).				
1913	...	...	...	...	28,167
1914	...	...	...	...	16,530
1915	...	...	...	...	4,477
1916	...	...	...	...	12,342
1917	...	...	...	...	14,614
1918	...	...	...	...	5,419
1919	...	...	...	...	

Mexico.

Zinc ores occur in many regions of Mexico, notably in the States of Chihuahua and San Luis Potosi, but lack of transport facilities and the remoteness of many of the known deposits of zinc and silver-lead-zinc ores have greatly retarded the expansion of the zinc-mining industry.

* Statistique Générale de la Tunisie (Annual).

Before the European war the disturbed condition of the country rendered all forms of mining difficult and dangerous, and the zinc mining industry suffered with the rest. At that time practically all the ore mined was shipped to the United States and Europe for treatment. During the war the great demand for zinc concentrates greatly stimulated zinc-mining in Mexico. The more settled condition of the country rendered it possible to increase exports of zinc ore to the record figure of 143,992 tons in 1916, the whole of which was shipped to the United States.

The United States International Zinc Ore Company had under construction at Saltillo during the year 1918 a distillation plant of 600 retorts. It is claimed that this is the first zinc-distilling furnace erected in Latin America.

*Exports of Zinc Ore from Mexico to the United States.**

Year.	Ore (long tons).			Zinc Content (long tons).
1913	...	...	15,603	5,500
1914	...	...	18,487	6,842
1915	...	...	51,517	15,896
1916	...	...	143,992	45,561
1917	...	...	129,784	40,801
1918	...	...	47,632	16,452
1919	...	...	29,860	10,022

United States.†

The United States has long been the chief producer of both zinc ore and spelter. Formerly, zinc mining was mainly confined to the States of Illinois, Iowa, and Wisconsin, known as the Upper Mississippi region, the Franklin Furnace mines of New Jersey, and the famous Joplin region in Missouri. Latterly, and to an increasing degree, the successful application of the flotation methods of zinc concentration, combined with improved smelting and refining processes, have rendered it possible to treat profitably the zinc contained in the large deposits of complex ores found in the western States.

The Joplin region is an indefinite area, comprising the southwestern portion of the State of Missouri together with portions of south-eastern Kansas and north-eastern Oklahoma. The ores mined consist of galena, zinc-blende, and the oxidation products of those minerals, and occur in horizontal sheets or blanket deposits of mineralized cherts in rocks of Lower Carboniferous age. In spite of the immense quantities of zinc ore extracted from these fields, the Joplin area still remains the premier zinc producing region in America.

The ores mined in the Upper Mississippi region occur in cavities in limestones and dolomites of Ordovician age or disseminated throughout such formations. The ore minerals are galena, zinc

* Figures taken from the Report of the U.S. Geological Survey.

† Mineral Resources of the United States (Annual). Foreign Commerce and Navigation of the United States (Annual).

blende, and calamine, associated with much iron pyrites, the presence of which makes roasting and electromagnetic separation necessary. The ore minerals of the important Franklin Furnace mines in New Jersey are of an unusual type, and consist of zincite, willemite, and franklinite, with no admixture of lead or cadmium. The ores from these mines are much used for the manufacture of zinc oxide and spiegeleisen. Before the war considerable amounts of these ores were exported to Europe, principally to Germany.

A large proportion of the spelter produced in the United States is obtained from the extensive deposits of complex zinc ores found in the western States, particularly Colorado, Idaho, Montana, California, and Utah. The ores occur mainly as replacement deposits or as fault-breccias and veins traversing limestones of Carboniferous age. They contain zinc, lead, silver, and copper, and are frequently auriferous. The principal mining regions are the sulphide belt in the San Juan region in Colorado, the Cœur d'Alene region of Idaho, and the Butte district of Montana.

Before the war the output of zinc, including zinc contained in ore exported to Europe, amounted to over 32 per cent. of the entire world's production. A little ore was imported from Canada, and Mexico shipped a considerable quantity to be treated in the United States, but the great bulk of the spelter produced was obtained from domestic ores.

During the war period there was a large expansion of the zinc industry in the United States. In normal years American production approximately balanced consumption. The rest of the world's supplies were derived chiefly from Germany and Belgium. The war caused a greatly increased demand for spelter for munition purposes and at the same time shut off the Belgian and German supplies. The demand was met by increased production and greatly increased shipments of zinc ore, chiefly from Australia and Mexico. At no time was there any shortage of zinc ores. Smelting capacity, on the other hand, was inadequate to meet the insistent demand for spelter; consequently, the price rose out of all proportion to the price paid for zinc ore. In the year 1913, when the production of spelter in America was about 309,000 tons, there were 111,458 retorts at zinc smelters to meet the extraordinary demand for spelter. Existing plants were greatly enlarged and numerous new smelting and refining works were erected. By the close of the year 1917, when production reached its highest level, there was sufficient smelting capacity in the United States to produce 800,000 tons of spelter per annum.

Increased smelting facilities in Canada, Australia, France, and the United Kingdom, together with over-production in America, combined to cause a heavy fall in spelter prices during the years 1917 and 1918. The output consequently diminished, and by the close of 1919 American production of spelter had fallen to 415,842 tons.

Production of Zinc Ore in the United States.

Year.	Zinc Ore.				Zinc-lead Ore.			All other Ore.			Total.	
	Crude ore (long tons).	Recoverable zinc content.		Per cent of total zinc derived.	Crude ore (long tons).	Recoverable zinc content.		Crude ore (long tons).	Recoverable zinc content.		Crude ore (long tons).	Recover- able zinc content. (long tons).
		Quantity (long tons).	Per- cent- age.			Quantity (long tons).	Per- cent- age.		Quantity (long tons).	Per cent. of total zinc derived.		
1913	10,441,204	290,030	2·8	77·7	1,274,131	80,422	6·3	21·5	38,074,591	3,103	49,789,926	373,555
1914*	—	—	—	—	—	—	—	—	—	—	—	363,356
1915	14,591,191	396,081	2·7	75·6	1,646,550	124,675	7·6	23·8	40,787,885	2,897	57,025,626	523,653
1916	19,006,002	459,560	2·4	73·3	2,442,293	157,892	6·5	25·0	53,453,244	9,329	74,901,539	626,781
1917	2,244,762	201,614	9·0	31·7	19,475,434	430,429	2·2	67·5	53,740,053	4,885	75,460,249	636,928
1918												
1919												

* Total recoverable zinc content only stated in 1914.

Secondary Zinc Produced in the United States.

	Quantity (long tons).							
	1913.	1914.	1915.	1916.	1917.	1918.	1919.	
Secondary spelter, redistilled	23,206	18,344	26,575	25,693	15,031	8,855	17,632	
Secondary spelter, remelted	21,441	20,021	20,657	18,783	13,004	15,348		
Recovered zinc in alloys (excluding old brass) remelted.	3,342	3,495	4,732	2,321	4,286			
Recovered zinc in remelted brass	23,056	22,106	30,692	55,089	71,429	9,895		
Secondary zinc recovered as metal	71,045	63,966	82,656	101,886	103,750			
Secondary zinc recovered in pigment	3,308	5,836	7,431	7,812	8,218			
Secondary zinc recovered in zinc chloride	5,583	5,740	7,018	5,642	5,579			
Total secondary zinc	79,936	75,542	97,115	115,340	117,547			

Spelter Produced in the United States from Domestic and Foreign Ores.

Year.	Quantity (long tons).			Value (£).		
	From Foreign Ore.	From Domestic Ore.	Total.	From Foreign Ore.	From Domestic Ore.	Total.
1913 ...	8,414	301,118	309,532	—	7,869,166	—
1914 ...	8,599	306,623	315,222	204,583	7,297,708	7,502,291
1915 ...	28,022	409,049	437,071	1,621,458	23,670,208	25,291,666
1916 ...	92,862	503,873	596,735	5,806,875	31,508,958	37,315,833
1917 ...	75,871	521,962	597,833	3,611,458	24,845,417	28,456,875
1918 ...	22,788	439,647	462,435	967,708	18,670,417	19,638,125
1919 ...	12,028	403,814	415,842	409,792	13,756,458	14,166,250

Production of Zinc Dust and Lithopone, and Primary Zinc Content of Zinc Pigments Manufactured in the United States.

Year.	Zinc Dust (long tons).	Lithopone (long tons).	Primary zinc content of zinc pigments (long tons).
1913	378	26,504	63,055
1914	896	29,303	63,053
1915	1,567	38,770	71,046
1916	2,329	51,961	80,604
1917	5,279	37,375	87,119
1918	6,246	55,717	
1919	5,891	64,732	

Galvanized Iron and Steel Sheets, Formed Products, and Tubes Produced in the United States.

Year.	Galvanized iron and steel sheets (long tons).	Galvanized* formed products (long tons).	Galvanized tubes (long tons).	Total. (long tons).
1913	824,047	57,674	266,940	1,148,661
1914	806,995	58,752	265,028	1,130,775
1915	706,058	50,086	280,944	1,037,088
1916	601,305	58,171	291,013	950,489
1917	568,740	51,296	275,305	895,341
1918				
1919				

* Articles formed or stamped from iron or steel sheets and galvanized after shaping.

Zinc Imported and Entered for Consumption in the United States.

Year.	Block or Pigs.		Sheets.		Old.		Value of Manufactures.* (£)	Total value.* (£)		
	Quantity (long tons).	Value* (£)	Quantity (long tons).	Value* (£)	Quantity (long tons).	Value* (£)				
1913	...	...	4,612	117,753	199	9,062	246	3,719	1,140	131,674
1914	...	...	174	4,404	247	6,668	346	5,523	930	17,525
1915	...	...	56	3,513	85	3,001	651	21,520	130	28,164
1916	...	...	19	924	2	90	573	23,386	173	24,573
1917	...	...	16	475	65	3,452	231	5,411	52	9,390
1918	...	...	10	604	0·63	6	13	308	69	987
1919	...	...	29	476	1	52	33	462	262	1,252

* Values converted to £ sterling at the rate of 1 dollar=4s. 2d.

Imports of Zinc Ore into the United States.

From	1913.			1914.			1915.		
	Ore (long tons).	Zinc content (long tons).	Value.* (£)	Ore (long tons).	Zinc content (long tons).	Value.* (£)	Ore (long tons).	Zinc content (long tons).	Value.* (£)
Canada ...	7,937	3,123	25,819	10,045	3,988	29,843	10,707	4,205	37,056
Australia ...	—	—	—	—	—	—	68,223	26,538	384,125
Belgium ...	1,495	1,427	13,535	—	—	—	—	—	—
France ...	—	—	—	—	—	—	—	—	—
Germany ...	1,391	751	11,470	—	—	—	—	—	—
Italy ...	—	—	—	—	—	—	4,743	1,897	31,956
Siberia ...	1,600	1,247	7,608	—	—	—	—	—	—
Spain ...	—	—	—	—	—	—	—	—	—
French Africa ...	—	—	—	—	—	—	—	—	—
Mexico ...	15,603	5,500	49,594	18,487	6,842	49,875	51,517	15,896	443,753
French East Indies ...	—	—	—	—	—	—	—	—	—
China and Hong Kong ...	—	—	—	—	—	—	5,250	2,445	24,982
Japan ...	—	—	—	—	—	—	1,222	446	16,229
Other Countries ...	15	3	33	6	2	20	170	62	1,596
TOTAL ...	28,041	12,051	108,059	28,538	10,832	79,738	141,832	51,489	939,697

* Values converted to £ sterling at the rate of 1 dollar = 4s. 2d.

Imports of Zinc Ore into the United States.

	1916.			1917			1918.			1919.		
	Ore (long tons).	Zinc con- tent (long tons).	Value.* (£)	Ore (long tons).	Zinc content (long tons).	Value.* (£)	Ore (long tons).	Zinc content (long tons).	Value.* (£)	Ore (long tons).	Zinc content (long tons).	Value.* (£)
Canada	19,551	7,848	118,179	14,784	4,603	70,556	13,381	4,619	66,628	9,514	3,463	24,161
Australia	101,662	45,179	671,497	24,759	11,163	156,999	—	—	—	—	—	—
Belgium	—	—	—	—	—	—	—	—	—	—	—	—
France	3,408	1,270	11,780	—	—	—	—	—	—	—	—	—
Germany	—	—	—	5,285	2,153	24,431	—	—	—	—	—	—
Italy	11,205	5,163	82,246	—	—	—	—	—	—	—	—	—
Siberia	—	—	—	—	—	—	—	—	—	—	—	—
Spain	49,969	20,608	322,986	13,195	5,431	54,359	—	—	—	—	—	—
French Africa	4,000	1,658	26,907	1,112	556	13,822	—	—	—	—	—	—
Mexico	143,992	45,561	1,204,076	129,784	40,801	591,086	47,632	16,452	250,424	29,860	10,022	72,092
French East Indies	1,476	666	11,543	—	—	—	—	—	—	—	—	—
China and Hong Kong	8,608	4,079	71,707	—	—	—	—	—	—	—	—	—
Japan	—	—	—	5	—	—	2,292	1,080	10,858	4,063	1,702	14,093
Other Countries	670	242	4,368	—	2	9	—	—	—	—	—	—
TOTAL	344,611	132,274	2,525,289	188,924	64,709	911,262	63,305	22,151	327,910	43,437	15,187	110,346

* Values converted to £ sterling at the rate of 1 dollar = 4s. 2d.

Zinc Dust, Zinc Oxide and Lithopone, Imported and Entered for Consumption in the United States.

Year.	Zinc Dust.		Zinc Oxide.			Lithopone.	
	Quantity (long tons).	Value.* (£)	Dry.		In Oil.	Quantity (long tons).	Value.* (£)
			Quantity (long tons).	Value.* (£)			
1913	2,114	51,767	2,938	85,519	127	2,262	31,871
1914	1,789	39,913	2,197	58,259	150	3,604	57,880
1915	631	28,640	762	30,879	26	1,898	30,118
1916	466	47,996	399	37,775	16	2,118	8,637
1917	208	10,126	106	10,969	4	204	7,441
1918	14	740	145	13,063	4	†	†
1919	46	1,199	94	9,237	3	660	25,564

* Values converted to £ sterling at the rate of 1 dollar = 4s. 2d.

† Not stated separately.

Exports of Zinc Ore and Manufactures from the United States (Domestic Produce.)

Year.		Zinc Ore.		Plates, Sheets, Pigs or Slabs.		Zinc Dross.		All other Manufactures.	Total Value.*
		Quantity (long tons).	Value.* (£)	Quantity (long tons).	Value.* (£)	Quantity (long tons).	Value.* (£)	Value.* (£)	
1913	...	(b) 15,815	131,665	6,949	199,097	25	304	30,413	361,479
1914	...	(b) 9,920	80,930	57,859	1,779,306	2,264	50,197	43,939	1,954,372
1915	...	(b) 743	7,349	105,896	6,153,683	3,720	105,616	406,656	6,673,304
1916	...	70	832	145,656	10,689,801	43	2,250	119,631	10,812,514
1917	...	1,179	13,134	137,318	7,986,783	11,877	443,106	118,823	8,561,846
1918	...	55	517	71,646	3,549,245	14,121	466,440	150,557	4,166,759
1919	...	—	—	115,632	4,736,699	4,574	154,020	112,111	5,002,830

(a) Not including brass.

(b) The exports consisted wholly of high-grade willemite ore from New Jersey.

* Values converted to £ sterling at the rate of 1 dollar = 4s. 2d.

Exports of Zinc from the United States (Foreign Produce).

Year.	Exported from Warehouse.						Exported in manufactures with benefit of drawback.
	Ore and Calamine Zinc contents.		Blocks, Pigs and Old.		All other manufactures.		Blocks, pig, sheets and all other manufactures.
	Quantity (long tons).	Value.* (£)	Quantity (long tons).	Value.* (£)	Value.* (£)	Quantity (long tons).	
1913	4,827	44,674	554	13,941	1,298	6,660	
1914	125	1,231	4,857	44,216	3,863	3,686	
1915	—	—	11,406	490,741	24,813	29	
1916	—	—	38,598	1,683,425	223	—	
1917	—	—	57,750	2,589,449	10	1,418	
1918	—	—	17,319	736,035	6,700	5,658	
1919	—	—	10,943	404,912	2,723	4,047	

* Values converted to £ sterling at the rate of 1 dollar = 4s. 2d.

Primary Spelter Consumed in the United States.

		Quantity (long tons).						
		1913.	1914.	1915.	1916.	1917.	1918.	1919.
Supply :—								
Stock, January 1st :—								
In bonded warehouses	...	43	—	99	28	80	28	—
At smelters	...	3,995	36,303	17,843	12,697	15,632	47,937	36,822
Production	...	309,532	315,222	437,071	596,735	597,833	462,435	415,842
Imports	...	5,446	786	807	611	230	31	63
TOTAL AVAILABLE		319,016	352,311	455,820	610,071	613,775	510,431	452,727
Withdrawn :—								
Exports (foreign) from warehouse	...	5,381	4,982	11,406	38,598	57,750	17,919	10,943
Exports (foreign) under drawback	...	6,660	3,686	29	—	1,418	5,658	4,047
Exports (domestic)	...	6,949	57,859	105,896	145,656	137,318	71,646	115,632
Stock, December 31st :—								
In bonded warehouses	...	—	99	29	81	28	—	—
At smelters	...	36,303	17,843	12,697	15,632	47,937	36,822	32,851
TOTAL WITHDRAWN		55,293	84,469	130,057	199,957	244,451	132,045	163,473
APPARENT CONSUMPTION		263,723	267,842	325,763	410,104	369,324	378,386	289,254

*Exports of Zinc Oxide from the United States.**

Year.	Quantity (long tons).	Value (£).
1913	12,917	236,720
1914	13,921	293,443
1915	17,847	430,922
1916	12,448	498,898
1917	13,791	656,020
1918	11,090	579,064
1919	13,129	638,020

China.†

The zinc-producing areas of China are all situated in the south-western provinces of Hunan, Kweichow, Szechuan and Yunnan, but the total annual output is small.

There is one important producer in Hunan, known as the Hunan mine, situated at Shui-Ko-Shan, south-west of Hang-cho-fu. This mine is owned by the Hunan Official Mining Board, but before the war it was under the control of Messrs. Carlowitz and Company, of Hankow.

The ore occurs as irregular deposits in Palæozoic limestone; the ore minerals are galena and zinc-blende, associated with iron and copper pyrites.

The mine is equipped with modern plant capable of treating more than 55,000 tons of ore yearly.

It is understood that all contracts with Messrs. Carlowitz and Company have been cancelled since the war, and that the concentrates produced are now mostly shipped to Japan for reduction.

Exports of Zinc from China.

Year.	Zinc Ore (long tons).	Zinc (long tons).
1913	9,396	893
1914	7,255	305
1915	8,406	2,291
1916	404	762
1917	224	425
1918	163	127
1919	2	107

French Indo-China.‡

Deposits of zinc ore are worked in Tonkin on an extensive scale. No reduction or smelting of the ores is carried out in the Protectorate, the dressed concentrates being exported chiefly to France, Japan, and the United States.

* Values converted to £ sterling at the rate of 1 dollar = 4s. 2d.

† Maritime Customs. Returns of Trade and Trade Reports (Annual).

‡ Statistique de l'Industrie Minérale en France et en Algérie (Annual).

The chief producing regions are the Tuyen-Quang at the junction of the Claire and Gam rivers, the Thai-Nyuyen region about 50 miles east of Tuyen-Quang, the Cho-dien district about 50 miles above Tuyen-Quang, and the Than-Moi area on the upper waters of the Song-Thuong. The average tonnage of zinc ore exported during the period under review may be taken at 20,000 to 30,000 tons annually.

Zinc ores have been mined in Annam, and deposits are known to exist in the Protectorate of Laos, but up to the present these deposits have not been mined.

Production of Zinc Ores in French Indo-China.

Year.	Quantity (long tons).	Value (£).*
1913	32,893	—
1914	30,994	122,840
1915	33,749	242,600
1916	48,040	525,400
1917	24,504 (a)	223,160
1918	28,190	
1919		

(a) Exports.

Japan.†

Formerly Japan produced zinc ore on a considerable scale from mines situated in the provinces of Hida, Etchu, Etchizen, and Mimasaka. Nearly the whole of the concentrates obtained were shipped to Europe, principally Belgium, for treatment. Japan produced no spelter, although both the Osaka-Ayen Company at Konoshima and the Mitsui Mining Company at the Miike Colliery had under construction modern smelting works. It was not until the year 1914 that Japan entered the list of spelter-producing countries.

During the war the Japanese smelting industry was greatly expanded. Considerable additions were made to the existing plants, and many new smelting works erected. The domestic supplies of ore were quite incapable of furnishing all the raw material required, but Japan was able to obtain all the concentrates needed from the Shui-Ko-Shan mines in China and the Broken Hill mines in Australia. During 1919 some of the new smelters were closed down.

The production of zinc by the electrolytic process has made some headway in Japan during the last few years, but although the zinc produced has been of high quality the cost of production has so far proved excessive.

* Values converted to £ sterling at the rate of 25 francs = £1.

† Statistical Reports of the Department of Agriculture and Commerce (Annual).

Production of Zinc and Zinc Ore in Japan.

Year.	Zinc Ore.		Zinc.	
	Quantity (long tons).	Value.* (£).	Quantity (long tons).	Value* (£).
1913	34,119	85,718	—	—
1914	13,911	28,235	5,807	136,902
1915	6,023	36,077	20,754	1,295,259
1916	2,152	18,306	38,297	2,721,575
1917	160	2,723	53,741	2,700,532
1918	—	—	39,203	1,773,093
1919	—	—	22,000†	—

Imports of Zinc into Japan.

Year.	Quantity (long tons).	Value* (£).
1913	10,787	305,407
1914	5,698	154,293
1915	3,402	159,345
1916	3,723	242,517
1917	5,617	295,800
1918	—	—
1919	—	—

Exports of Spelter from Japan.

To	1917.	1918.	1919.
British India	1,983	3,464	264
Great Britain... ..	18,729	4,116	3,789
France	5,858	6,971	—
China	1,265	369	1,285
Other Countries	8,276	1,729	234
TOTAL	36,111	16,649	5,572

* Values converted to £1 sterling at the rate of 10 yen = £1.

† Estimated.

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APPENDIX.

THE ZINC INDUSTRY AT THE CLOSE OF 1919.

By GILBERT RIGG.

The position of the zinc industry at the close of 1919 presents some peculiarly interesting features. Prior to the war, for all practical purposes, there was only one method of producing the metal, namely, the distillation process. Electrothermic furnaces existed in Scandinavia, and the Canadian Government had carried out a considerable amount of experimental work along this line, but without achieving any results of commercial importance. The possibilities of leaching and electrolysis had been discussed and tried out for more than a quarter of a century, but, in spite of numerous attempts ranging in scale from laboratory experiments to more ambitious efforts reaching in at least one case to very large expenditure indeed, the effect upon the industry was so small as to be negligible.

Amongst those who were closely associated with the production of spelter on the large scale by the distillation process, there was a marked tendency to scepticism as regards the feasibility of these innovations, and perhaps not altogether without reason. In the past the advocates of the new regime were not infrequently given to magnifying the claims for recognition of their particular schemes by emphatically drawing attention to defects in the distillation process which had ceased to exist years ago. This applied more especially to limitations as to the grades of ore which the latter process was capable of treating, whilst, as a matter of fact, a feature of its development during the past 20 years has been the inclusion of less and less desirable raw material in the class of commercially available ores. With this had gone improvements in furnace design, resulting in increased capacity and fuel economy, and improved recoveries, until, in spite of the fact that the productive equipment unit still remained a retort, the content of which was measured in pounds instead of tons, the operating costs and tonnages possible with modern plant did not compare so unfavourably, after all, with the figures afforded by other non-ferrous metals. And yet during the period covered by the war the electrolytic process has at last arrived, and, in the opinion of the writer, has come to stay. And, as not infrequently occurs in the history of an industry, this new phase of spelter-making has arisen outside the spelter industry, and has been developed by parties that were in no way concerned with spelter production. Neither the Anaconda Copper Co. nor the Trail Consolidated Smelters owned or operated a single spelter furnace, whilst the Electrolytic Zinc Co. of Australasia is a new corporation formed expressly to carry on the production of spelter in this way.

With success, however, has come a certain modesty. We hear much less often nowadays the story that the electrolytic process can deal with "low-grade mixed ores" impossible for the older process. The leaching of the zinc from the ore is no longer a matter of a few stirring tubs, but calls for carefully prepared raw materials, good engineering, and a well-applied knowledge of physical chemistry.

The position of the electrothermic processes is not so clear. These labour under the same disadvantage as the distillation process, namely, that the reduction of zinc from its ores requires a temperature higher than the boiling point of the metal. Consequently the metal is driven off as

vapor, and requires to be condensed, and, as every spelterman knows, this condensation is one of the delicate points about the metallurgy of zinc. The mere driving off of the metal from the ore is relatively easy. The catching of it in a form in which it can be cast into merchantable slabs is a problem of another order, and the successful condensation of the zinc vapor is a more difficult and complicated matter in the case of electrothermic smelting than in the case of the old distillation process.

Whilst wishing all success to those who are striving hard to place the electrothermic processes in the forefront, in discussing the zinc position as it appears at the close of 1919, these processes can hardly be considered as taking rank with the distillation and electrolytic methods, and our discussion will therefore be confined to these two. And it would appear to be not unprofitable to attempt at the outset to set down, so far as can be done at present, the factors which limit the spheres of application of each.

The great bulk of the world's supply of zinc ore occurs in the form of zinc-blende, or sulphide of zinc, and for either form of treatment this sulphide of zinc must be roasted to oxide. Seeing that this necessity is common to both, and also that, whilst the best practice differs somewhat in the two cases, the cost is substantially the same whether roasting for distillation or electrolytic, we can for the moment eliminate this stage from the discussion and confine ourselves strictly to the treatment of the roasted ore by the distillation process and by the electrolytic. In the former case our basic elements are fuel, equipment for developing the heating power of the fuel as fully as possible and furnaces to utilize this heating power as economically as possible consistent with due economy of labour and material and due regard to first cost. In the latter we require electrical power generated as economically as possible together with effective leaching equipment designed to make the best possible extraction of the zinc from the ore and to deliver it to the depositing cells in the form of a solution as nearly chemically pure as possible.

Hence, we have in the two processes corresponding and interchangeable terms, cheap fuel in the case of the distillation process and cheap power in the case of the electrolytic. Distillation plants tend to congregate on coal-fields or on territory where natural gas is available, whilst the electrolytic process has been established where water-power is obtainable. This fact affords one explanation why the electrolytic process was developed outside the existing spelter industry, namely that water power is in general remote from distillation plants and raising power from coal did not appear to be attractive from the point of view of economy.

In good distillation practice, using a fair grade of roasted ore and a reasonable quality of soft coal in modern gas-producers, one ton of roasted ore will require one ton of coal. This figure has been beaten, but it is a reasonably conservative one to take. Taking Broken Hill zinc concentrates for example, and allowing a furnace recovery of 85 per cent. on a zinc content of 52 per cent. in the roasted ore, we should require $2\frac{1}{4}$ tons coal per ton of spelter. In addition to this, however, is required coal to mix with the ore in order to reduce the oxide to metal. This may be taken as 0.4 ton coal per ton of ore, or, on Broken Hill concentrates, 0.9 ton coal per ton of spelter. Hence, the total coal consumed for firing the furnace and reducing the ore amounts to 3.15 tons per ton of spelter.

In electrolytic practice one horse-power day will produce 10 lb. zinc. This is also a reasonably conservative figure. Taking 30 lb. coal per horse-power day, which would require very high class modern equipment to achieve, we should require 3 tons coal per ton of spelter or 15 tons less coal per ton spelter than in the case of the distillation process. And as against the up-to-date gas-producer plant required in the latter process we should need an up-to-date power plant. True, the electrolytic process needs no pottery to make retorts and condensers, but on the other hand the distillation process needs no leaching plant. It will perhaps help to

clear up the position if we set down the essential elements of the two types of plant in parallel column:—

DISTILLATION PLANT.

1. Coal, ore and clay handling and stocking equipment.
2. Charge mixing and handling equipment.
3. Pottery, including retort and condenser-making and drying plant.
4. Gas producers and gas distributing plant.
5. Spelter furnaces, including charging and metal-drawing-and-handling machines.

ELECTROLYTIC PLANT.

1. Coal and ore handling and stocking equipment.
2. Leaching and solution purifying and handling plant.
3. Power-house, including boilers, turbo-generators and power distribution plant.
4. Electrolytic cells, including electrodes and conductors and cathode handling apparatus.
5. Cathode melting furnaces.

For a production of 100 tons of spelter per day from Broken Hill roasted concentrates by the distillation process we should require a furnace plant of 9,000 retorts of 1·5 cubic feet capacity each, which at 300 retorts per furnace would mean 30 furnaces with a producer plant to gasify 225 tons coal per day.

For a similar production by the electrolytic process we should require a power installation of 22,500 horse-power together with leaching equipment to deal with 225 tons roasted ore per day and electrolytic cell plant to deposit 100 tons metal daily.

This comparison will serve to indicate in a very general way the relative size and shape of the two plants.

In three respects the electrolytic process has a distinct advantage over the distillation.

In the first place, in the distillation process there is a certain loss of zinc over and above that remaining in the residues. Part of this loss is due to the absorption of zinc into the walls of the retort and part to the loss of zinc vapor escaping from the condenser. In general, these two losses will together amount to from 5 per cent. to 10 per cent. of the zinc in the ore, according to the class of ore and the furnace practice. So far no economical method of recovering the zinc so lost has been discovered.

In the electrolytic process these losses do not occur. All the zinc which does not find its way into solution and so to the electrolytic cells is found in the residues. Even the dross made in melting down the cathodes is available for profitable re-treatment. There is, however, one counter-weighing advantage to the distillation process. If the residues are to be treated for the recovery of their metallic contents by furnacing (and so far no other economical method is known) then the charge coal remaining in the distillation residues will be directly available, whilst in the case of the electrolytic residues fuel must be supplied. The cost of fuel will obviously influence materially the amount of the advantage.

In the second place we have the question of labour. No one who has had experience of the two processes can fail to be impressed with the contrast between the demands made on the operatives. The difference is all in favour of the electrolytic process. With a well laid out plant on a reasonable scale (not less than 50 tons spelter per day) it is possible to reduce the amount of operating labour to a minimum, whilst all heavy or arduous work is absent. There is no heat or dust or gas to contend with. Men of moderate physique are just as suitable for the work as men of powerful build and endurance. Lastly, the purity of the metal is independent of the purity of the ore. The nature of the electrolytic process demands that the purification of the zinc solution shall be carried to a high pitch of perfection; and naturally the zinc produced from this solution is likewise pure. This enables the metal to be used for purposes for which the common metal is unsuited, except at the additional cost of re-distillation.

On the other hand it must be pointed out that the cost of the power plant, especially under present day conditions, would be exceedingly heavy, and that the cost of power includes many other items besides the cost of the coal.

Even so brief a review as the foregoing is sufficient to indicate that a comparison between the relative advantages of the two processes is a complicated matter. And no comparison will stand which does not take into account the possibilities of eliminating more or less the disadvantages at present associated with the distillation process. The writer is convinced that considerable possibilities exist here.

The electrolytic process in its successful phase is a very recent matter. It has started up, stimulated by high-priced metal, without the handicap of pre-existing plants, which must be scrapped if the new method succeeds. It has had lavished on it a vast amount of skilled research—of brains and of capital. The question arises what would have happened if the distillation process had been tackled in the same way? Is the present heavy consumption of coal essential? What can be done to render the work at the furnace front less arduous? How far can mechanical equipment economically replace manual labour?

To answer such questions even very briefly makes it necessary to deal somewhat with technicalities, but the underlying principles are simple enough to be followed by those who have not specialized in the industry, and a clear understanding of them is essential if the future possibilities of the distillation process are to be appreciated.

Firstly, as regards fuel consumption. Referring once more to Broken Hill concentrates, and bearing in mind that one ton of coal is necessary to work off one ton of the roasted concentrates, if we calculate the number of British Thermal Units necessary to reduce the zinc produced, we find that the figure obtained amounts to 8.5 per cent. of the British Thermal Units contained in the coal used. A small part of this loss of heat is due to other reactions taking place in the retort, and a larger part still to losses in the gas producer, but the greater part is inherent to the process as we work it to-day.

Many causes contribute to this undesirable state of affairs. The walls of the retort are poor conductors of heat—the charge itself is a good deal worse conductor. These two facts explain why so small a proportion of the heat necessary to keep the furnace hot actually finds its way into the charge, and does useful work. Then as the charge becomes poorer and poorer in zinc as the operation progresses, the yield of metal from the retort becomes less and less, but coal must still be burned to keep up the temperature of the furnace. Consequently, if the retorts could be made of materials having a better conductivity for heat, and the conductivity of the charge could be improved and the falling off in the yield as the charge is working off, could be minimized, improvements in coal economy would follow.

As regards the first of these possibilities, the substitution of carborundum retorts for fire clay ones shows improved conductivity as well as increased life of the retorts, but whether, having regard to the much higher first cost of the former, the substitution is truly economical, remains to be proved.

Improvement in conductivity of the charge itself has been obtained at the Port Pirie Plant of the Broken Hill Associated Smelters' Proprietary, Ltd., by the introduction of blast roasting. This method of roasting, which will be described later, delivers the roasted ore in lumps of finely porous sinter instead of in fine particles. These lumps are crushed through a $\frac{3}{8}$ -in. screen before being charged into the retort, and, in consequence of the relative coarseness of the charge as compared with that usually employed, the circulation of the reducing gases in the retort is greatly improved, and heat is carried much more freely by these gases from the hot walls of the retort to the interior of the charge. In consequence, the con-

ductivity of the charge is very substantially increased and the consumption of firing coal per ton of ore diminished.

Lastly, the question of diminished yield during the later stages of the operations demands careful consideration if this source of fuel loss is to be minimized. The reasons for this falling off are easy to understand. As the retort is heated from the outside, and the conductivity of the charge is low, it follows that the outer layers of the charge will come up to working temperature first and that the last part of the charge to reach this temperature will be the centre, and, furthermore, owing to the poor conductivity of the charge, the flow of heat reaching the centre will be a good deal slower than that reaching the outside layers. Consequently, in the later stages of the process the yield falls off, because the amount of zinc contained in the centre of the charge is relatively small, and the flow of heat to it is relatively slow.

The following theorem results from these considerations: That for any charge and any retort dimensions there is a certain percentage recovery of zinc which is the most economical, and that a recovery lower or higher than this is accompanied by a falling off in economy. The problem of the calculation of this optimum recovery is an exceedingly complicated one, and it is doubtful whether sufficient knowledge is available at present to carry it out successfully. The most economical size and shape of retort enters as an important factor, as does also the method of charging and discharging. The method of treatment of the relatively rich residues for the recovery of as much as possible of the zinc they contain in useful form needs further working out. It is quite possible that with some ores the preliminary treatment of the ore before it goes to the roasting furnaces with a view to influencing the nature of the distillation residues, and so the product derived from them, will be a paying proposition.

Another interesting possibility is the application of what may be called "by-product" gases to the smelting of zinc ores, the gases from the iron blast furnaces for example. These are, in general, poorer than the producer-gas used in zinc smelting, but the addition of 10 to 15 per cent. of by-product coke-oven gas would bring them up to the necessary grade.

In trying to arrive at the best possible application of these gases, those processes which absolutely depend upon gas-firing should, other things being equal, receive first consideration. Boilers can be economically fired with solid fuel fed by automatic stokers. Open-hearth steel-furnaces can be fired with pulverized fuel. Spelter furnaces absolutely depend upon gas-firing.

The possibility of firing spelter furnaces in this way offers many attractions. The costly gas-producer plant would be done away with together with the labour and maintenance associated with its operation, and the whole plant and its operation greatly cheapened and simplified thereby.

Coming now to the question of labour. There is no doubt whatever that men are much less inclined to work under arduous conditions for long hours than formerly, and show a marked reluctance, with which all right-minded men must sympathize, to earn a living by work which involves risk to their health. A good deal has been done of late years to minimize the strain of work at the furnace front, and the following is an attempt to summarize the lines on which improvement has been made and on which further improvement may be looked for.

In the first place, the proper design of the furnaces and regulation of the temperature so as to minimize retort breakages is essential. About the hottest and most disagreeable work about a spelter furnace is the removal of retorts which have been badly damaged by heat and by the slagging of their contents. These retorts are usually in a sticky condition and offer a stubborn resistance to being pulled out of the furnace. In this connection the way in which the ore has been roasted plays an important part. The higher the percentage of sulphur left in the roasted ore, the

more the liability to retort disaster and its accompanying unpleasantness.

This is an additional argument for the study of the most economical recovery referred to above. By the avoidance of very high temperatures towards the end of the operation, the tendency to troubles of this kind will be minimized.

The substitution of mechanical charging machines for putting the ore into the retorts instead of hand-charging has also made some progress, and further development along this line will undoubtedly come. It must be borne in mind, however, that out of the entire time required to complete the manœuvre of changing retorts, drawing residues, taking down and setting up condensers, and charging the retorts, the latter operation takes only a comparatively small fraction, and consequently the gain in time by the substitution of machine for hand labour is not likely to be large. Moreover as the work is carried out to-day, the same men usually take part in all the operations enumerated above, and consequently, if full advantage is to be taken of mechanical equipment, the reorganization of the labour force must go with it.

Mechanical appliances for drawing residues have not yet reached an advanced stage, and more work is needed to develop them. Metal-drawing machines, on the other hand, are now the rule in America, the ladle being carried on a travelling crane and the operator being protected from the heat by a suitable shield.

Above all, full and free ventilation of the furnace room is a *sine qua non*. The system of bringing fresh air into the furnace room by ducts, which deliver the air to the working places by down-comers, has been used for years by the New Jersey Zinc Company of America with excellent results.

Lastly there comes the question of roasting. First-class work on the distillation furnaces is only possible when the ore has been well roasted and the elimination of sulphur is reasonably complete. The roasting of zinc-blende ores and the production of sulphuric acid from the roaster gases is not as simple as it looks, and the indications are that substantial changes are imminent.

Zinc-blende is itself a fuel, both the zinc and the sulphur giving out heat during the process of oxidation to zinc oxide and sulphur dioxide respectively. In the case of the Broken Hill zinc concentrates already referred to, the ore contains substantially more heat units than are necessary to bring it, and the air required to roast it, to the necessary temperature. Nevertheless the use of a considerable amount of coal, ranging for the most part to from 20 to 40 per cent. of the weight of the ore, has in the past been found necessary to bring down the sulphur to the requisite point.

The reason for this lies in the slowness with which the last few units of sulphur are reached by the air and oxidized. These units exist to a large extent in the interior of grains of ore which have been oxidized on the outside, and so to a considerable extent protected from further oxidation. Further, unoxidized grains are more or less buried in the layer of oxidized material on the furnace hearth. Hence the rate of oxidation is too slow to keep up the temperature of the ore to a level at which roasting can be carried on and coal must be used.

It has been found during a series of large-scale trials carried on in Australia that Broken Hill concentrates can be roasted down from 30 per cent. to 8 per cent. sulphur in a multiple-hearth muffled furnace with a coal consumption not exceeding 5 per cent. Moreover there are strong grounds for believing that the use of even this small amount can be avoided if the furnace be suitably modified. If this partially roasted ore is then charged on to a blast-roasting machine, in which air, instead of passing over the ore, is drawn or forced through it, the sulphur content can be brought down to 1 per cent. in less than half-an-hour, at the expense of a further 1 per cent. of fuel necessary to ignite the charge. The air, passing through the charge, instead of over it, is able to come in contact with the unroasted or partly-roasted grains, and so to rapidly

eliminate the residual sulphur. The roasted product takes the form of the finely porous sinter referred to above.

Both the preliminary roaster and the final blast-roaster have large capacity when operated in this way, and each is used during that stage in the elimination of the sulphur at which its efficiency is at a maximum. This system of roasting has been successfully in use at the plant of the Broken Hill Associated Smelters in South Australia for the past two years.

The course of the spelter industry at home and abroad during the next five years would need someone upon whom the mantle of prophecy had descended to deal with adequately. In 1913 the world's output of spelter was substantially 1,000,000 tons. America produced 320,000 tons, Germany 280,000 and Belgium 200,000. The production of primary metal in the United Kingdom was about 30,000 tons. In 1917 America produced 700,000 tons, and whilst some of this was produced in plants which were hurriedly put together under the temptation of the high prices due to the war, and which will probably not be re-opened, the greater part of the increase represents substantial plant, backed by ample capital accumulated during the period of high prices. The situation is further complicated by the action of the United States Steel Corporation, one of the largest consumers of spelter, which established its own smeltery in 1915, and will doubtless aim to take care of its own requirements.

Belgium is at present hampered by high-priced fuel and shortage of ore. Improvement in the shipping position will help to remedy this, and the Belgian furnaces will doubtless become increasingly important factors in the world's supply. Australia will be to the fore with 30,000 tons per annum of high-grade zinc, whilst there is talk of the Anaconda Copper Company increasing its plant from its present production of from 150 to 200 tons per day by a further 100 tons per day. Japan, for the present, anyway, seems to have retired from the field. France is handicapped even more severely than Belgium at present, and the spelter industry in France is not so much of a tradition as in Belgium. Norway, with its ample supply of cheap water-power, will undoubtedly be heard from if not through the electrothermic processes, then through the electrolytic. Germany and Poland, it may be supposed, will sooner or later be in the field.

Moreover, the relation which the production of high-grade zinc suitable for cartridge brass and other refined applications bears to that of common spelter will undergo a marked change in the future owing to the development of electrolytic plants. In 1913 the world's production of spelter containing over 99.9 per cent. of zinc probably did not exceed 25,000 tons per annum. In the course of the next two years the production will probably be in the neighbourhood of 150,000 tons. The price differential between the two grades has already undergone a marked diminution, and the effect of large increases in the supply of high-grade metal will undoubtedly be adversely felt by the common grades.

Taking the mean annual increase in the world's production of spelter over the 10 years 1904 to 1913 inclusive, and applying it to the years 1914 to 1919 inclusive, we obtain a figure of 1,200,000 tons for 1919.

It is safe to say that if all the available productive capacity of the world in the way of plant and suitable labour had been in operation, the rate of output at the close of 1919 would have exceeded this figure, and further, having regard to the prospective increases in productive equipment now developing, the consumption of spelter might fairly be expected to lag behind the available productive capacity for some time to come. However, plant capacity is one thing and production another, for it is evident from the figures now available that production during 1919 did not amount to 60 per cent. of the total capacity.

With Germany, Belgium and France practically out of production, the United Kingdom working at a very low level and serious reductions in the United States output, the year closed with threats of a serious world

scarcity of the metal which could only be countered by considerable advances in prices. Even now the position of supplies, if not precarious, is at least difficult, and must remain so until world transport—whether on land or by sea—improves to such an extent as to enable the free movement of ores and concentrates to the smelting plants now standing idle.

What is going to be the position of England's spelter industry in the next five years? If we are going to compete successfully, having regard to high cost of fuel and materials, and high cost of labour and labour difficulties, we must start to put our house in order. Fuel and labour are going up in price all over the world. The relation of labour to the general scheme of production is changing, and generating more or less friction in the process, and the successful competitors will be those who have tackled the problem of spelter production most radically, and with the least regard to hampering tradition.
